COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH

THE NEW ZEALAND JOURNAL OF SCIENCE AND TECHNOLOGY

A. AGRICULTURAL RESEARCH SECTION

VOLUME 30.—No. 3 OCTOBER, 1948

Printed for the Department of Scientific and Industrial Research, Wellington,
by
Coulls Somerville Wilkie Ltd., Dunedin, N.Z.
March, 1950

COMMONWEALTH MYCOLOGICAL
12 OCT 1950

REGISTERED AT G.P.O., WELLINGTON, AS A MAGAZINE

THE NEW ZEALAND

Journal of Science and Technology

VOLUME 30, No. 3, 1948

(AGRICULTURAL RESEARCH SECTION)

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NOTICES

SUBSCRIPTIONS.—Subscriptions payable in advance. Volume 30, 1948. Series A, 10s. per annum; Series B, 10s. per annum; Series A and B, 15s. per annum. Vol. 31, 1949: Series A, 20s. per annum; Series B, 10s. per annum; Series A and B, 25s. per annum; Single copies, 2s.; postage, 1d. Subscriptions should be paid by money-order, postal note, bank note or cheque, and should be forwarded to the Publications Officer, Department of Scientific and Industrial Research, P.O. Box 562, Dunedin. Cheques should be made payable to the Department of Scientific and Industrial Research, and when payable at banks other than in Dunedin should have exchange (6d.) added. Subscribers are requested to furnish their full names and addresses.

CORRESPONDENCE.—All communications relative to the Journal should be addressed to the Editor, Department of Scientific and Industrial Research, Wellington.

THE NEW ZEALAND
JOURNAL OF SCIENCE
AND
TECHNOLOGY

Editor: N. A. Marris, M.Sc., B.Com. (Assistant Editor: A. J. Healey, M.Agr.Sc.) Department of Scientific and Industrial Research, Wellington

VOL. 30, SEC. A | OCTOBER, 1948 | NUMBER 3

FURTHER INVESTIGATIONS ON THE NUTRIENT STATUS OF FLUE-CURED TOBACCO

By H. O. ASKEW, R. T. J. BLICK, KATHLEEN E. CURRIE and JOYCE WATSON, Cawthron Institute, Nelson

(*Received for publication, 21st December, 1948*)

Summary

Harrison's Special variety of flue-cured tobacco was grown on two soil types for three seasons to determine the course of development of dry matter and of intake of nutrients by the plants.

When young, the plants were well-supplied with minerals and nitrogen (on the dry-matter basis) but were relatively low in percentage of dry matter. As they developed the percentage of dry matter increased in both leaves and stalks but the concentration of minerals and nitrogen generally decreased; lime however accumulated in leaves near the base of the plant. There were distinct differences in chemical composition between leaves and stalks at all stages of growth.

The maximum amount of dry matter and of minerals was found shortly after harvesting began. Production of dry matter and intake of nutrients continued during the harvesting period; from one-third to one-half of the season's absorption of nutrients occurred at this time.

On the heavier soil intake of minerals and nitrogen was such that plants on it generally showed a higher nutrient status than those on the lighter soil.

Seasonal conditions during harvesting greatly influenced the production of dry matter and absorption of nutrients.

Cured leaf from successive harvests showed appreciable differences in chemical composition; variations from one season to another were apparently due to unidentified seasonal influences.

After completion of harvesting the residual plant material is of considerable value for use as a green manure.

A discussion of the present three seasons' and a previous two seasons' results is presented.

INTRODUCTION

A report on "The Nutrient Status of Flue-Cured Tobacco", published in 1944 (1), covered work carried out with plants of Harrison's Special variety in the seasons 1941-42 and 1942-43. Since that time, until the 1946-47 season, work of a similar type has been continued. Further refinements in experimental procedure have been introduced with the result that a number of points mentioned in the earlier report as requiring confirmation or elucidation can now be discussed with a greater probability of arriving at sound conclusions. Moreover the longer experimental period has enabled the effects of varying types of growing and harvesting seasonal conditions to be more clearly seen.

The present paper covers the three seasons 1944-45, 1945-46 and 1946-47. Although a similar trial was run in the 1943-44 season the results are not reported because they are not considered to be satisfactory, due mainly to difficulties that were experienced in drying the samples in that season. In the last three seasons plants of the same origin were grown on two soil types, a medium sand loam and a silt loam, to compare the development of the plants and the intake of nutrients under these two conditions.

EXPERIMENTAL

In each of the three seasons reported upon in this paper the plants for the experimental areas were provided by the Tobacco Research Station at Riwaka. Harrison's Special variety was grown. In 1944-45 season the strain was the same as that used in 1941-42 and 1942-43, but in the 1945-46 and 1946-47 seasons another strain, giving a broader type of leaf, was used. It is therefore necessary to compare the results of the 1944-45 season's results with those reported previously (1) rather than with those of the last two seasons.

Two soil types were used in the work of the last three seasons listed above, the medium sand of the Tobacco Research Station and a silt loam soil of a commercial grower. Both areas were sufficiently near to one another for the rainfall conditions to be considered the same. At the Research Station the same plot of ground was planted for these experiments in the three seasons. On the grower's soil a different area, damper and likely to be colder in the spring, was used in the last two seasons from that set out in 1944-45. Plants in each season were obtained from the same seedling bed and were set out in the field as nearly as possible on the same day. The planting dates for the three seasons were 24th November, 1944, 3rd December, 1945 and 3rd December, 1946. Fertilizer equivalent to 1,000 lb. per acre of a 3-8-8 mixture was applied in the rows before planting. Spacing of the plants was 24 in. in rows 3 ft. 6 in. apart. The usual cultural operations were given, including irrigation when required on the medium sand.

The number of plants taken as a sample at any one date varied with their size, but was never less than ten, even with fully grown plants. Roots were not included, the plants being cut off at ground level. Separations into leaves and stalks were made at each sampling until harvesting began. From then onwards separations were made into ripe and green leaves, laterals and stalks in the 1944-45 seasons, and into ripe, nearly ripe and green leaves, toppings, laterals and stalks in the 1945-46 and 1946-47 seasons. At each harvest usually three leaves were taken in the "ripe" leaf sample; similarly three leaves were taken for the "nearly ripe" leaf sample, the assumption being that these "nearly ripe" leaves would be the "ripe" leaves at the next harvest. Also the number of leaves on an average plant was recorded after topping. At subsequent sampling dates only average-sized plants with the requisite number of leaves were taken for sample material. By this means it was expected that more accurate sampling would be obtained. Ripe leaf from the area at the Research Station was picked by the Station staff after the sample plants were obtained. This leaf was cured and provided material for analysis representing the successive harvests from the plants. The same number of leaves per plant was removed for these harvests as was taken as "ripe" on the plants for laboratory examination. Cured leaf was analysed for minerals and nitrogen contents, as were the other separates of plant material, and also for glucose, fructose and sucrose contents.

Monthly totals of rainfall for the three seasons under review are given in Table I and a more detailed record of the distribution of the rainfall by weekly periods in Fig. 1. The 1944-45 season was wet in the spring and during the harvesting period of January and February. November and December were not unduly wet. Temperatures and hours of bright sunshine were low in the spring and early summer. No irrigation water was applied in this season. In 1945-46 the spring rainfall was low and this lack of rain continued into the growing and harvesting season. Most of the December rainfall occurred in the first ten days of the month. Both January and February were unusually dry, the latter month providing only 0.56 in. of rain. Over an inch of rain fell in the first few days of March and further rain fell later. This, combined with the previous very dry period, caused unsatisfactory harvesting conditions. Some relief from the dry conditions of January was obtained on the medium sand by applying irrigation water equivalent to approximately one inch of rain on each of two occasions, namely 15th and 30th January, 1946. In the third season there was a sufficiency of soil moisture up to November, 1946. Most of the rain recorded fell before the middle of the month. From then onwards there were long dry periods in December, January, February and March. Up to the end of December the season was unusually cold but later the weather was warm and sunny, causing a rapid ripening of the leaf. The crop was irrigated at the previously mentioned rate on 29th January, 1947.

TABLE I. RAINFALL IN INCHES AT THE TOBACCO RESEARCH STATION FOR THE SEASONS 1944-45, 1945-46, 1946-47 AT MONTHLY INTERVALS

Season.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	Total.
1944–45	3.16	8.65	2.44	3.57	5.05	8.35	2.09	2.32	35.63
1945–46	3.83	3.45	1.71	2.96	1.13	0.56	3.73	8.71	26.08
1946–47	5.47	8.04	2.27	1.35	1.93	1.94	2.19	8.29	31.48

A. 1944-45 SEASON

In this season the same strain of Harrison's Special variety was grown as in the 1941-42 and 1942-43 trials. Owing to the unusually wet spring and low temperatures early in the season the difference between the rates of growth of the plants on the two areas was greater than might otherwise have been the case. During January and February when the leaf was maturing there were some very heavy falls of rain (Table I and Fig. 1). As already stated it was unnecessary to irrigate the plants at the Research Station.

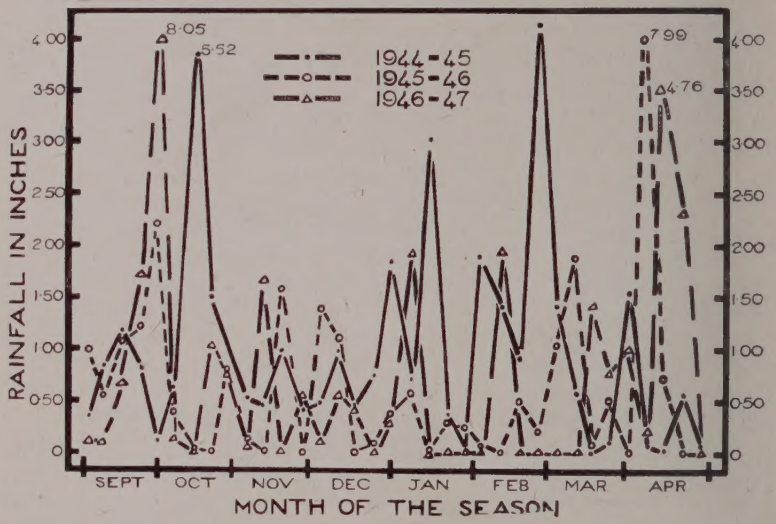

FIG. 1.—Rainfall at weekly intervals for the seasons 1944-45, 1945-46 and 1946-47.

Yield of Dry Matter :

Data for yield of dry matter calculated in terms of grams per plant and pounds per acre and for percentage of dry matter in the leaves and stalks are given in Table II for the Research Station trial. After setting of the plants in the field on 24th November, 1944, no samples were taken until 10th January, 1945, i.e., 47 days after planting, the plants then being about 15 in. high. At this stage the leaves provided about seven-eighths of the total dry matter of the plants. Percentage of dry matter was 10.52 per cent. in the leaves and only 7.13 per cent. in the stalks, with a plant average of 9.92 per cent. The average dry matter per plant was 27.38 g. In the next few weeks the plants grew rapidly, with increasing percentages of dry matter in both leaves and stalks ; moreover the stalks now formed a larger proportion of the total weight of the plant. At the time of the first harvest on 31st January, 1945, 68 days after planting, the plants were about 45 inches high and were yellowing on account of the dry weather. The stalks comprised almost one-third of the total weight of the plant while the average weight of dry matter per plant had increased to 108.6 g. Moreover the separation made into sand leaves, ripe leaves and green leaves showed that the percentage of dry matter increased in this order, the stalks having an appreciably lower percentage. After harvesting began the amount of leafage on the plants decreased from one date of sampling to the next, but the stalks continued to increase in weight until the end of the season. The last harvest was made on 6th March, 102 days after setting of the plants in the field.

TABLE II. NUTRIENT INTAKE EXPERIMENT 1944-45 SEASON, TOBACCO RESEARCH STATION, MEDIUM SAND SOIL.
Yield of Dry Matter and Percentage of Dry Matter

Date of Sampling.	Part of Plant.	Dry Matter per cent.	Dry Matter per plant. gm.	Dry Matter per acre. lb.
24/11/44	Whole	5.16	0.43	5.65
10/1/45	Leaves	10.52	23.93	316.5
	Stalks	7.13	3.45	45.6
	Whole	9.92	27.38	362.1
17/1/45	Leaves	14.79	39.34	520.3
	Stalks	7.59	8.68	114.8
	Whole	12.63	48.02	635.1
24/1/45	Leaves	14.09	57.07	754.9
	Stalks	9.51	19.14	253.1
	Whole	12.57	76.21	1008.0
31/1/45	Sand Leaves	13.50	10.36	137.0
	Ripe Leaves	14.12	19.03	251.7
	Green leaves	18.92	43.28	572.5
	Stalks	12.02	35.90	474.8
	Whole	14.69	108.57	1436.0
7/2/45	2 ripe leaves	16.89	13.45	177.9
	Green leaves	18.57	41.51	549.1
	Toppings leaves	18.19	6.75	89.3
	Toppings stalks	11.94	11.46	151.6
	Stalks	14.49	48.09	636.1
	Whole	15.79	121.26	1604.0
14/2/45	2 ripe leaves	19.03	14.90	197.1
	7 green leaves	19.34	30.80	407.4
	Stalks	15.71	53.97	713.9
	Whole	17.15	99.67	1318.4
27/2/45	3 ripe leaves	17.46	18.72	247.6
	4 green leaves	17.54	18.56	245.5
	Laterals	12.82	21.04	278.3
	Stalks	15.39	49.34	652.6
	Whole	15.43	107.66	1424.0
6/3/45	4 ripe leaves	18.23	16.58	219.3
	Laterals	12.54	23.11	305.7
	Stalks	17.70	60.95	806.2
	Whole	16.24	100.64	1331.2

For the silt loam soil data corresponding to those given above for the Research Station are presented in Table III. Samples were taken mostly on the same dates from both areas; direct comparisons of the development of the plants are therefore readily obtained. During the first 68 days after planting the yield of dry matter per plant was lower on the silt loam than on the medium sand, but from this date onward the plants on the heavier soil rapidly increased in weight due especially to the development of very heavy stalks. Thus by the end of the season the stalks of these plants were fifty per cent. greater in size than those on the lighter soil. During most of the season the plants on the silt loam showed percentages of dry matter in the leaves lower by from

three to nearly five per cent. than those for corresponding dates on the medium sand. Stalks showed similar, though smaller, differences. At the end of the season the stalks showed little difference but the leaves from the plants on the two areas still were markedly different in dry matter content.

TABLE III. NUTRIENT INTAKE EXPERIMENT 1944-45 SEASON, LIGHT-PHASE SILT-LOAM SOIL

Yield of Dry Matter and Percentage of Dry Matter

Date of Sampling.	Part of Plant.	Dry Matter per cent.	Dry Matter per plant. gm.	Dry Matter per acre. lb.
24/11/44	Whole	5.16	0.43	5.65
10/1/45	Leaves	7.51	16.16	213.7
	Stalks	6.82	2.66	35.2
	Whole	7.40	18.82	248.9
17/1/45	Leaves	10.30	34.78	460.0
	Stalks	7.42	6.63	87.7
	Whole	9.70	41.41	547.7
24/1/45	Leaves	10.87	51.78	684.9
	Stalks	8.25	17.95	237.4
	Whole	10.05	69.73	922.3
31/1/45	4 Ripe leaves	13.55	24.85	328.7
	Green leaves	16.22	36.86	487.5
	Laterals and sand leaves	11.42	18.83	249.1
	Stalks	10.68	30.59	404.6
	Whole	12.89	111.13	1469.9
7/2/45	4 Bottom leaves	13.09	31.10	411.4
	Leaves	16.26	52.87	699.3
	Stalks	12.33	55.16	729.6
	Whole	13.77	139.13	1840.3
14/2/45	4 Bottom Leaves	13.82	28.48	376.7
	Leaves	16.08	71.31	943.2
	Stalks	14.38	69.35	917.3
	Whole	14.94	169.14	2237.2
22/2/45	3 Ripe leaves	11.99	16.72	221.2
	Leaves	15.89	86.21	1140.3
	Laterals	10.54	16.96	224.3
	Stalks	15.26	78.22	1034.6
	Whole	14.62	198.11	2620.4
6/3/45	3 Ripe leaves	12.06	16.40	216.9
	Leaves	14.51	70.92	938.1
	Laterals	11.76	44.86	593.3
	Stalks	18.02	95.53	1263.6
	Whole	14.82	227.71	3011.9

A comparison of the yields of dry matter for these two areas clearly shows the greater development of the plants on the heavier soil. The full season's figures were not obtained for plants on the latter area because harvesting ceased on 6th March. At this time the plants were obviously still growing rapidly, whereas at this time the Research Station area had been completely harvested. It is of interest to note that the heavier soil produced nearly twice as much dry matter as the lighter one.

Chemical Composition of Plant Separates :

Determinations of the mineral and nitrogen contents of leaves and stalks from the Research Station are set out in Table IV, the figures given being calculated on a sand-free dry-matter basis. Early in the season the plants were rich in all the constituents determined, this being especially marked in the case of potash. The maximum figures for leaves and stalks, 47 days after planting were respectively 6.08 per cent. and 7.86 per cent. As the plants developed there was a marked tendency for the percentages of magnesia, phosphoric acid, potash and nitrogen to fall. On the other hand lime increased in the lowest leaves to a maximum of 5.13 per cent. CaO ; leaves higher up the plant were poorer in lime, even though there was a tendency for leaves near the top of the plants to show an increase in lime content. Stalks progressively became poorer in all constituents until the harvest on the 82nd day after planting, after which they remained essentially of a constant composition, this being soluble ash, 6.7 per cent., lime, 0.9 per cent., magnesia, 0.3 per cent., phosphoric acid, 0.4 per cent., potash, 3.1 per cent. and nitrogen, 1.0 per cent.

TABLE IV. CHEMICAL COMPOSITION OF TOBACCO, NUTRIENT INTAKE EXPERIMENT, TOBACCO RESEARCH STATION 1944-45 SEASON
Expressed as percentage on sand-free dry matter basis

Date of Sampling.	Part of Plant.	Insoluble Ash.	Soluble Ash.	Lime CaO.	Magnesia MgO.	Phosphoric Acid P_2O_5.	Potash K_2O.	Total Nitrogen N
24/11/44	Whole	0.11	15.09	2.79	0.78	0.97	6.08	2.68
10/1/45	Leaves	0.65	17.82	3.66	1.08	0.76	6.08	3.47
	Stalks	0.11	15.66	1.36	0.58	0.75	7.86	2.45
17/1/45	Leaves	0.57	14.85	3.22	0.87	0.66	5.29	2.83
	Stalks	0.04	13.36	1.30	0.50	0.58	6.59	1.87
24/1/45	Leaves	0.37	11.72	2.48	0.64	0.59	4.29	1.92
	Stalks	0.10	11.52	1.12	0.46	0.59	5.88	1.41
31/1/45	Sand Leaves	0.97	17.81	5.13	1.10	0.48	3.63	1.30
	Ripe leaves	0.71	13.50	3.40	0.75	0.49	4.53	1.33
	Green leaves	0.19	8.90	1.55	0.42	0.60	3.72	1.76
	Stalks	0.09	8.87	1.01	0.40	0.55	4.34	1.17
7/2/45	2 Ripe leaves	0.19	10.10	2.65	0.40	0.62	3.37	1.56
	Green leaves	0.15	9.03	1.85	0.43	0.61	3.60	1.94
	Top leaves	0.01	10.05	1.74	0.54	0.94	4.45	3.31
	Toppings	0.00	10.65	1.04	0.61	1.07	5.22	2.72
	Stalks	0.03	7.74	1.01	0.37	0.47	3.80	0.99
14/2/45	2 Ripe leaves	0.08	9.46	2.28	0.48	0.54	3.53	1.66
	7 Green leaves	0.00	9.45	2.10	0.48	0.59	3.81	2.17
	Stalks	0.01	6.57	0.89	0.31	0.45	3.07	1.03
27/2/45	3 Ripe leaves	0.03	11.32	2.84	0.78	0.61	3.90	2.44
	4 Green leaves	0.08	11.95	3.08	0.91	0.55	3.64	2.81
	Laterals	0.07	20.15	2.26	0.89	0.87	5.08	3.61
	Stalks	0.17	7.08	0.98	0.33	0.38	3.29	1.05
6/3/45	4 Ripe leaves	0.03	12.29	3.47	0.89	0.68	3.54	2.42
	Laterals	0.00	14.47	2.74	0.93	0.88	5.55	3.49
	Stalks	0.08	6.40	0.95	0.32	0.34	2.92	0.97

Chemical data for plants from the silt-loam soil are given in Table V, where it will be seen that in the early samplings the leaves and stalks were very similar in composition to corresponding material from the Research Station plants grown on a medium sand. As the plants developed some significant differences appeared. Thus on the heavier soil the soluble ash and nitrogen were present in greater concentration and the lime contents of the leaves taken towards the end of the season were very high, the maximum figure being 8.25 per cent. CaO. Potash contents were similar for each corresponding set from the two areas. It is interesting to note the very high potash content, 5 per cent. K_2O or more, of the young laterals in both series of samples. In general there were no very consistent differences between the concentrations of magnesia and phosphoric acid in the two sets of data.

TABLE V. CHEMICAL COMPOSITION OF TOBACCO, NUTRIENT INTAKE EXPERIMENT, LIGHT-PHASE SILT-LOAM SOIL, 1944-45 SEASON

Expressed as percentage on sand-free dry matter basis

Date of Sampling.	Part of Plant.	Insoluble Ash.	Soluble Ash.	Lime CaO.	Magnesia MgO.	Phosphoric Acid P_2O_5.	Potash K_2O.	Total Nitrogen N.
24/11/44	Whole	0.11	15.09	2.79	0.78	0.97	6.08	2.68
10/1/45	Leaves	0.29	17.66	3.62	0.75	0.79	6.68	4.18
	Stalks	0.12	15.87	1.46	0.52	0.83	7.91	3.04
17/1/45	Leaves	0.09	17.24	3.94	0.70	0.72	6.25	4.04
	Stalks	0.18	14.33	1.68	0.48	0.66	7.10	2.52
24/1/45	Leaves	0.23	15.14	3.65	0.64	0.71	5.26	3.28
	Stalks	0.09	12.43	1.37	0.41	0.62	6.09	2.15
31/1/45	4 Ripe leaves	0.61	14.58	3.97	0.47	0.47	4.68	2.22
	Green leaves	0.03	9.49	2.04	0.34	0.68	3.78	2.95
	Laterals and sand leaves	0.65	17.65	4.87	0.69	0.53	5.21	2.51
	Stalks	0.04	9.43	1.22	0.27	0.59	4.50	1.71
7/2/45	4 Bottom leaves	0.18	16.02	4.99	0.57	0.43	4.38	2.24
	Leaves	0.05	11.22	2.97	0.37	0.53	3.87	2.79
	Stalks	0.07	9.16	1.38	0.32	0.46	4.22	1.61
14/2/45	4 Bottom leaves	0.34	16.60	5.64	0.60	0.44	4.08	2.01
	Leaves	0.16	12.30	3.63	0.43	0.55	3.78	2.80
	Stalks	0.06	7.22	1.24	0.29	0.44	2.15	1.46
22/2/45	3 Ripe leaves	0.40	19.46	6.85	0.74	0 45	4.15	2.03
	Green leaves	0.09	13.10	4.20	0.45	0.51	2.96	2.53
	Laterals	0.04	12.64	2.02	0.54	1.07	5.39	4.07
	Stalks	0.02	6.83	1.23	0.32	0.39	3.03	1.32
6/3/45	3 Ripe leaves	0.04	22.02	8.25	0.86	0.41	3.82	2.25
	Leaves	0.11	15.40	5.18	0.56	0.48	2.74	2.75
	Laterals	0.15	11.80	1.96	0.50	0.80	4.67	3.42
	Stalks	0.02	5.95	1.08	0.25	0.30	1.74	1.16

Intake of Nutrients:

From the yield of dry matter and the chemical composition of the plants the intake of nutrients is readily calculated. Nutrient status of the plants at the two locations is given in Tables VI and VII. In

the earlier stages of growth the greatest demand was for potash, lime and nitrogen, the demand decreasing in this order. At all stages the demand for potash was double that for lime or nitrogen. Uptake of magnesia and phosphoric acid was at a much lower level.

TABLE VI. NUTRIENT STATUS ON PER PLANT BASIS, MEDIUM SAND SOIL, TOBACCO RESEARCH STATION, 1944-45 SEASON

Expressed in grams on sand-free dry matter basis

Date of Sampling.	Part of Plant.	Insoluble Ash.	Soluble Ash.	Lime CaO.	Magnesia MgO.	Phosphoric Acid P_2O_5.	Potash K_2O.	Total Nitrogen N.
24/11/44	Whole	0.001	0.064	0.012	0.003	0.004	0.025	0.011
10/1/45	Leaves	0.16	4.26	0.88	0.26	0.18	1.45	0.83
	Stalks	0.004	0.54	0.05	0.02	0.03	0.27	0.08
	Whole	0.164	4.80	0.93	0.28	0.21	1.72	0.91
17/1/45	Leaves	0.22	5.84	1.27	0.34	0.26	2.08	1.11
	Stalks	0.003	1.16	0.11	0.04	0.05	0.57	0.16
	Whole	0.223	7.00	1.38	0.38	0.31	2.65	1.27
24/1/45	Leaves	0.21	6.69	1.42	0.37	0.34	2.45	1.10
	Stalks	0.02	2.20	0.21	0.09	0.11	1.13	0.27
	Whole	0.23	8.89	1.63	0.46	0.45	3.58	1.37
31/1/45	Sand leaves	0.09	1.85	0.53	0.11	0.05	0.38	0.13
	Ripe leaves	0.13	2.57	0.65	0.14	0.09	0.86	0.25
	Green leaves	0.08	3.85	0.67	0.18	0.26	1.61	0.76
	Stalks	0.04	3.18	0.36	0.14	0.20	1.56	0.42
	Whole	0.34	11.45	2.21	0.57	0.60	4.41	1.56
7/2/45	2 Ripe leaves	0.02	1.36	0.36	0.05	0.08	0.45	0.21
	Green leaves	0.06	3.75	0.77	0.18	0.25	1.49	0.81
	Top leaves	0.00	0.68	0.12	0.04	0.06	0.30	0.22
	Toppings	0.00	1.22	0.12	0.07	0.12	0.60	0.31
	Stalks	0.02	3.72	0.49	0.18	0.23	1.83	0.48
	Whole	0.10	10.73	1.86	0.52	0.74	4.67	2.03
14/2/45	2 Ripe leaves	0.01	1.41	0.34	0.07	0.08	0.53	0.25
	7 Green leaves	0.00	2.91	0.65	0.15	0.18	1.17	0.67
	Stalks	0.005	3.55	0.48	0.17	0.24	1.66	0.56
	Whole	0.015	7.87	1.47	0.39	0.50	3.36	1.48
27/2/45	3 Ripe leaves	0.006	2.12	0.53	0.15	0.11	0.73	0.46
	4 Green leaves	0.01	2.22	0.57	0.17	0.10	0.68	0.52
	Laterals	0.01	4.24	0.48	0.19	0.18	1.07	0.76
	Stalks	0.09	3.49	0.48	0.16	0.19	1.62	0.52
	Whole	0.116	12.07	2.06	0.67	0.58	4.10	2.26
6/3/45	4 Ripe leaves	0.005	2.04	0.58	0.15	0.11	0.59	0.40
	Laterals	0.00	3.34	0.63	0.21	0.20	1.28	0.81
	Stalks	0.05	3.90	0.58	0.20	0.21	1.78	0.59
	Whole	0.055	9.28	1.79	0.56	0.52	3.65	1.80

TABLE VII. NUTRIENT STATUS ON PER PLANT BASIS, LIGHT-PHASE SILT-LOAM SOIL, 1944-45 SEASON

Expressed in grams on sand-free dry matter basis

Date of Sampling	Part of Plant.	Insoluble Ash.	Soluble Ash.	Lime CaO.	Magnesia MgO.	Phosphoric Acid P_2O_5.	Potash K_2O.	Total Nitrogen N.
24 11 44	Whole	0.001	0.064	0.012	0.003	0.004	0.025	0.011
10 1 45	Leaves	0.05	2.85	0.58	0.12	0.13	1.08	0 68
	Stalks	0.01	0.42	0.04	0.01	0.02	0.21	0.08
	Whole	0.06	3.27	0.62	0.13	0.15	1.29	0.76
17/1/45	Leaves	0.03	6.00	1.37	0.24	0.25	2.17	1.41
	Stalks	0.01	0.95	0.11	0.03	0.04	0.47	0.17
	Whole	0.04	6.95	1.48	0.27	0.29	2.64	1.58
24/1/45	Leaves	0.12	7.84	1.89	0.33	0.37	2.72	1.70
	Stalks	0.02	2.23	0.25	0.07	0.11	1.09	0.39
	Whole	0.14	10.07	2.14	0.40	0.48	3.81	2.09
31/1/45	4 Ripe leaves	0.15	3.62	0.99	0.12	0.12	1.16	0.55
	Green leaves	0.01	3.50	0.75	0.13	0.25	1.39	1.09
	Laterals and sand leaves	0.13	3.32	0.92	0.13	0.10	0.98	0.47
	Stalks	0.02	2.88	0.37	0.08	0.18	1.38	0.52
	Whole	0.31	13.32	3.05	0.46	0.65	4.91	2.63
7 2 45	4 Bottom leaves	0.06	4.98	1.55	0.18	0.13	1.36	0.70
	Leaves	0.03	5.93	1.57	0.20	0.28	2.05	1.48
	Stalks	0.04	5.05	0.76	0.18	0.25	2.33	0.89
	Whole	0.13	15.96	3.88	0.56	0.66	5.74	3.07
14 2/45	4 Bottom leaves	0.09	4.73	1.61	0.17	0.13	1.16	0.57
	Leaves	0.12	8.77	2.59	0.31	0.39	2.70	2.00
	Stalks	0.04	5.01	0.86	0.20	0.31	1.49	1.01
	Whole	0.25	18.51	5.06	0.68	0.83	5.35	3.58
22/2/45	3 Ripe leaves	0.07	3.25	1.15	0.12	0.08	0.69	0.34
	Green leaves	0.08	11.29	3.62	0.39	0.44	2.55	2.18
	Laterals	0.01	2.14	0.34	0.09	0.18	0.91	0.69
	Stalks	0.02	5.34	0.96	0.25	0.30	2.37	1.03
	Whole	0.18	22.02	6.07	0.85	1.00	6.52	4.24
6/3/45	3 Ripe leaves	0.01	3.61	1.35	0.14	0.07	0.63	0.37
	Leaves	0.08	10.92	3.67	0.40	0.34	1.94	1.95
	Laterals	0.07	5.29	0.88	0.22	0.36	2.09	1.53
	Stalks	0.02	5.68	1.03	0.24	0.29	1.66	1.11
	Whole	0.18	25.50	6.93	1.00	1.06	6.32	4.96

While the data on the per plant basis are of more interest to the investigator than corresponding figures on a per acre basis, the latter have a value to the agriculturist in showing the demand on the soil for nutrients provided from its own resources or from those in conjunction with added fertilizer. By using the factor 13.227 data on the gram per plant basis may be calculated to a pounds per acre basis, assuming that 6,000 plants were set out per acre. Nutrient status of the whole plants for the various sampling periods is given below in Table VIII, the quantities of each nutrient being expressed in pounds per acre.

Table VIII. Nutrient Status of Plants, in Pounds per Acre, 1944-45

Location.	Date of Sampling.	Soluble Ash lb.	Lime CaO lb.	Magnesia MgO lb.	Phosphoric Acid P_2O_5 lb.	Potash K_2O lb.	Nitrogen N. lb.
Medium sand	24/11/44*	0.86	0.16	0.04	0.05	0.33	0.15
	10/1/45	63.5	12.3	3.7	2.8	22.8	12.0
	17/1/45	92.6	18.3	5.0	4.1	35.1	16.8
	24/1/45	117.6	21.6	6.1	6.0	47.4	18.1
	31/1/45	151.4	29.2	7.5	7.9	58.3	20.6
	7/2/45	141.9	24.6	6.9	9.8	61.8	26.9
	14/2/45	104.1	19.4	5.2	6.6	44.5	19.6
	27/2/45	159.6	27.3	8.9	7.7	54.2	29.9
	6/3/45	122.8	23.7	7.4	6.9	48.3	23.8
Silt loam	24/11/44*	0.86	0.16	0.04	0.05	0.33	0.15
	10/1/45	43.3	8.2	1.7	2.0	17.1	10.0
	17/1/45	91.9	19.6	3.6	3.8	34.9	20.9
	24/1/45	133.2	28.3	5.3	6.3	50.4	27.7
	31/1/45	176.2	40.0	6.1	8.6	64.9	34.8
	7/2/45	211.1	51.3	7.4	8.7	75.9	40.6
	14/2/45	244.8	66.9	9.0	11.0	70.8	47.4
	22/2/45	291.3	80.3	11.3	13.3	86.2	56.1
	6/3/45	337.3	91.7	13.2	14.0	83.6	65.6

* Date of planting in the field.

The data of Table VIII show that during the period of most rapid growth at the Research Station the plants were accumulating potash at the rate of about 1 lb. of K_2O per acre per day and nitrogen and lime at about half this rate. Magnesia and phosphoric acid were being absorbed at the rate of only 0.2 lb. per acre per day. But on the heavier soil potash was being taken up at the rate of more than 2 lb. per acre per day. Nitrogen and lime rates were 1-1½ lb. per day. Magnesia and phosphoric acid were being absorbed at about the same or slightly lower rate than at the Research Station. Once harvesting began on 31st January at the Research Station the state of affairs on the two areas was quite different. Due to removal of ripe leaves and a lower rate of absorption the quantity of nutrients in later samples from the Research Station was generally lower than at 31st January, but on the silt loam accumulation of nutrients proceeded at rates as great as or greater than those in the earlier period. This was due to the continued rapid development of dry matter on this area. Harvesting did not begin here until 22nd February.

Discussion :

Analysis of the detailed data for periods after harvesting began shows that ripe leaves removed at any one harvest had a lower percentage of dry matter than the remaining leaves but that in passing towards the top of the plant there was a tendency for the ripe leaves to approach more closely to the dry matter content of the remainder. This difference in composition was particularly well-marked on the heavier soil.

Examination of the data for development of dry matter after harvesting began at the Research Station shows that increases, as set out in Table IX, occurred during the periods between the first and the second dates of each line of the table, these increases being calculated from the total weight of remaining leaves and stalk, after removal of ripe leaves on the first date, but including ripe leaves on the second date. It is clear that this should be done because " nearly ripe " leaves of the first date of any pair will become the " ripe " leaves picked on the second date.

TABLE IX. INCREMENTS OF DRY MATTER IN POUNDS PER ACRE BETWEEN SUCCESSIVE SAMPLINGS

Location.	Period.	Rainfall in	Total Dry Matter Increment lb.	Leaf Dry Matter Increment lb.
Medium sand	31/1/45-7/2/45	1.85	556.7	243.8
	7/2/45-14/2/45	1.45	133.2	55.4
	14/2/45-27/2/45	0.89	302.7	85.7
	27/2/45-6/3/45	4.50	154.8	26.2
	Totals	8.69	1147.4	411.1
Silt loam	31/1/45-7/2/45	1.85	370.4	294.5
	7/2/45-14/2/45	1.45	396.9	209.2
	14/2/45-22/2/45	0.89	383.2	41.6
	22/2/45-6/3/45	4.50	391.5	15.3
	Totals	8.69	1542.0	560.6

These data demonstrate plainly the continued growth of stalk and laterals at the Research Station (medium sand) as compared with the development of harvestable leaves, the increment for harvestable leaves falling rapidly after 7th February. In other words, leaves left on the plant for later harvests did not grow very much in the time intervening between one harvest and the next. Doubtless the dry weather in February reduced the rate of growth not only of harvestable leaves but of the plants as a whole. On the silt loam rapid growth continued during February until the first harvest on the 22nd. These plants had been topped at about four feet high about 10 days previously. After the first harvest was taken there was a very marked drop in dry matter increment of the leaves. Rain came too late for it to have a marked effect on growth before 6th March, the date of the last recorded figures. Stalks and laterals continued to develop rapidly even though leaf growth was restricted.

Changes in chemical composition of the leaves and other parts of the plants occurred also after harvesting began. On the medium sand lime, magnesia and potash decreased in the leaves during ripening until about the middle of the plant was reached (third harvest). The two former constituents then increased with increasing maturity of the leaves but potash tended to decrease slightly. Phosphoric acid and nitrogen increased in percentage in passing from lower to upper leaves ; the former tended to increase but the latter to decrease during maturation of the leaves. On the heavier soil lime and magnesia increased in concentration in leaves nearer the top of the plant and also increased during maturation. Phosphoric acid and nitrogen decreased in percentage

Table X. Chemical Composition of Cured Leaf from Successive Harvests, Tobacco Research Station, 1944 45 Season

Constituents expressed as percentage on sand-free dry matter basis

Date of Sampling.	Soluble Ash.	Insoluble Ash.	Lime CaO.	Magnesia MgO.	Phosphoric Acid P_2O_5.	Potash K_2O.	Total Nitrogen N.	Glucose.	Fructose.	Sucrose.	Total Sugars.	Ratio, Total Sugars : Total Nitrogen.
Blades												
31 1 45	11.11	0.18	3.64	0.68	0.40	2.74	1.41	13.51	14.88	5.99	34.38	24.4
7 2 45	9.89	0.22	3.04	0.51	0.49	2.78	1.86	15.18	12.94	4.49	32.61	17.5
14 2 45	10.27	0.26	2.91	0.49	0.56	2.66	2.04	14.04	11.22	0.00	25.26	12.4
1 3 45	10.49	0.16	3.11	0.64	0.61	2.47	2.67	9.23	7.48	1.80	18.51	6.9
7 3 45	12.72	0.33	4.08	0.84	0.53	2.97	2.89	7.86	5.70	0.98	14.54	5.0
Midribs												
31 1 45	17.77	0.19	3.41	0.87	0.50	6.47	1.27	9.83	9.26	4.76	23.85	18.8
7 2 45	15.67	0.17	2.78	0.65	0.62	6.47	1.37	12.66	7.13	2.77	22.56	16.5
*14 2 45	15.05	0.13	2.89	0.78	0.83	5.53	1.94	10.39	4.04	n.d	·	·
1 3 45	16.71	0.17	3.31	1.11	0.95	5.77	1.92	7.86	3.25	1.05	12.16	6.3
*7 3 45	17.86	0.19	3.53	1.14	0.79	6.31	1.31	6.06	2.35	0.52	8.93	6.8

* Samples overheated in drying oven.

amount during ripening and were relatively constant in passing from lower to upper leaves. Potash tended to decrease towards the top of the plant, but to increase during maturation of the leaves; the content of potash remained relatively constant however at about 4 per cent. K_2O.

From the detailed data on the amounts of the several nutrients in the ripe and unripe leaves and in the stalks and laterals it is demonstrable that right through the season, even after harvesting began, accumulation of nutrients still took place, often to an appreciable extent, although of course the plants were carrying fewer leaves after each succeeding harvest. This was true for the total intake at both locations. From the more complete data for the medium sand area it is clear that nutrients continued to pass into the leaves during ripening. For lime, magnesia and phosphoric acid the intake by the plant after harvesting began comprised for each of these constituents approximately half the intake for the whole season; for soluble ash and potash the proportion was two-fifths and for nitrogen three-fifths. Thus in the latter case more nutrient was absorbed after harvesting began than in the earlier portion of the season. On a daily basis the increments of nutrient for magnesia and phosphoric acid averaged about 0.2 lb. per acre per day but for lime, potash and nitrogen the average was about one pound per acre per day. Over corresponding periods on the silt loam, with the continued rapid growth, the rate of intake reached double that for the medium sand.

On each occasion that ripe leaves were available the experimental area was picked over by the Research Station staff after the whole plants had been cut for analytical work. These leaves were flue-cured in the same manner as the crop of the Station. Each harvest was kept separate and samples of cured leaf were made available for analysis at the end of the season. This material was examined for minerals, nitrogen and sugars contents. The leaves having been separated into blade and midrib portions renders it impossible to make a direct comparison with the minerals and nitrogen data for the ripe (whole) leaves from the plants selected in the field. Analyses of cured leaf separates, blade and midrib for each of the five harvests of the 1944-45 season are given in Table X.

Taking, first, comparison of blade with midrib, it is noted that the latter is outstandingly rich in potash, there being more than twice as much in the midrib as in the blade. The midrib is also very rich in soluble ash. Lime content is approximately the same in both portions of the leaves but magnesia and phosphoric acid are present in greater amounts in the midribs; on the other hand nitrogen is usually appreciably greater in the blade. In respect of changes with successive harvests, soluble ash, lime, magnesia and potash show higher figures for early and late harvests than for intermediate ones. Phosphoric acid and nitrogen tend to increase in passing from lower to upper leaves; the last sample however appears to be aberrant in the midrib for these constituents.

Glucose, fructose and sucrose are higher in the blade than in the midrib. Two samples of midrib were unfortunately apparently overheated during drying in the laboratory so that the sugars data for these are somewhat doubtful. High figures for sugars are shown for the first three sets of samples. There is a marked tendency for sugar content to fall, especially in respect to sucrose, after the second harvest.

This combined with increasingly large nitrogen contents, especially in the blade, results in the ratio of total sugars to total nitrogen showing a marked decline with each successive harvest. The ratios for later harvests are such that the leaf is indicated to be of poor quality for cigarette purposes.

B. 1945-46 and 1946-47 Seasons

It has already been stated above that in these two seasons a different, broader leaved strain of Harrison's Special variety of tobacco was used than the one previously grown at the Research Station. Moreover a comparison of development of the plant and nutrient status has been made on two neighbouring soil types. More detailed records have been kept also during the experiments than previously.

In both seasons the plants were set out on 3rd December. The 1945-46 season was an exceptionally dry one and irrigation water was supplied on 15th and 30th January, 1946, at the Research Station. On the heavier soil of the commercial grower's property no supplementary water was used. Over most of the growing and harvesting period in 1946-47 the weather was dry. At the Research Station the crop was irrigated on 29th January, 1947. No water was supplied to the crop on the heavier soil.

Yield of Dry Matter

(*a*) *Medium Sand* (*Tobacco Research Station*):

Yield of dry matter in terms of grams per plant and pounds per acre, and percentage of dry matter, in the various separates from the plants at the Tobacco Research Station in the 1945-46 season are shown in Table XI. It will be noted that the young plants were very high in dry matter content as compared with previous seasons. At the first sampling after setting in the field (at 44 days on 16th January, 1946) the percentage of dry matter in the leaves was still relatively high but that of the stalks had fallen to a level near that previously recorded for young plants. Growth had been fairly satisfactory in spite of the rather cold but fairly dry December. No doubt the warmth and dryness of January had brought the plants ahead. At this time they were 12-14 in. high and had 7 formed leaves. The weekly samplings show that rapid growth continued through January and February. Thus between 16th January and 23rd January the plants doubled in height. By the end of the month they were sending up flower stalks. When the first harvest of ripe leaves was made on 11th February the average dry matter per plant was 185.47 g., this being equivalent to 2453.2 lb. per acre. The dry matter content of the ripe leaves was 15.59 per cent. with unripe leaves showing nearly 19 per cent. Maximum yield of dry matter in leaves was reached at the sampling on 25th February, in spite of the previous removal of six ripe leaves from the plant. By this time too the stalks had almost reached their greatest weight. In keeping with the dry conditions the percentages of dry matter in the leaves at the end of February and in March were very high, the maximum figures being 23.0 per cent. for ripe and 25.9 per cent. for nearly ripe leaves. It is noticeable that on every occasion ripe leaves showed a percentage of dry matter, usually lower by about one per cent., than that of nearly

TABLE XI. NUTRIENT INTAKE EXPERIMENT 1945-46 SEASON, TOBACCO RESEARCH STATION, MEDIUM SAND SOIL

Yield of Dry Matter and Percentage of Dry Matter

Date of Sampling.	Part of Plant.	Dry Matter per cent.	Dry Matter per plant. gm.	Dry Matter per acre. lb.
3 12 45	Whole	24.32	0.98	13.0
16 1 46	Leaves	14.94	29.81	394.3
	Stalks	8.74	4.53	59.9
	Whole	13.66	34.34	454.2
23 1 46	Leaves	13.76	52.57	695.3
	Stalks	8.34	11.12	147.1
	Whole	12.33	63.69	842.4
30/1/46	Leaves	16.22	81.26	1074.8
	Stalks	9.41	22.50	297.6
	Whole	14.00	103.76	1372.4
6 2 46	Leaves	17.88	92.71	1226.3
	Stalks	11.97	46.44	614.3
	Whole	15.35	139.15	1840.6
11/2/46	3 Ripe Leaves	15.59	20.53	271.5
	3 Near ripe leaves	18.98	29.77	393.8
	13 Green leaves	18.76	65.54	866.9
	Stalks and flower head	14.76	69.63	921.0
	Whole	16.71	185.47	2453.2
18/2/46	3 Ripe leaves	17.04	25.57	338.2
	3 Near ripe leaves	17.50	32.39	428.4
	10 Green leaves	20.80	57.10	755.3
	Toppings (13/2/46)	15.82	10.57	139.8
	Stalks	13.96	67.73	895.9
	Whole	16.64	193.36	2557.6
25/2/46	3 Ripe leaves	23.00	42.95	568.1
	3 Near ripe leaves	25.94	39.95	528.4
	7 Green leaves	21.29	37.57	496.9
	Laterals	20.75	6.12	80.9
	Stalks	16.69	86.83	1148.5
	Whole	20.01	213.42	2822.8
5/3/46	2 Ripe leaves	21.07	23.65	312.8
	3 Near ripe leaves	22.21	29.37	388.5
	5 Green leaves	22.31	36.03	476.6
	Laterals	11.21	11.54	152.6
	Stalks	15.75	73.28	969.3
	Whole	17.85	173.87	2299.8
12/3/46	3 Ripe leaves	20.25	32.71	432.7
	3 Near ripe leaves	21.38	25.63	339.0
	2 Green leaves	21.75	13.16	174.1
	Laterals	11.03	20.73	274.2
	Stalks	17.43	86.72	1147.0
	Whole	17.42	178.95	2367.0
26/3/46	5 Ripe leaves	20.49	33.72	446.0
	Laterals	13.51	71.87	950.6
	Stalks	22.88	121.11	1601.9
	Whole	18.49	226.70	2998.5

ripe leaves. In this season the yield of dry matter was higher than had been previously recorded at the Research Station and approximated the figure obtained on the silt loam in 1944-45. It is seen from Table XI that 19 leaves per plant were left after topping and that all of these were eventually harvested as ripe leaf, the last samples being obtained on 26th March, 113 days after the plants had been set in the field. The quantity of laterals at this date was unusually high, as was the figure for dry matter content of the stalks.

Yield data and percentages of dry matter in the plant separates for the 1946-47 season are set out in Table XII. At the beginning of this season growth appears to have been slower than in 1945-46, due probably to the long dry period from mid-November onwards. By mid-January the plants were 9-12 in. high, and by 6th February, 1947, they were beginning to send up flower stalks. Harvesting began on 11th February, the same date as in the previous season, but the total dry matter in the plants in 1947 was only 157 g. compared with 185 g. the year before. In spite of the dry weather the percentages of dry matter in the leaves at this date were lower than in the latter season by from 3 to 5 per cent. At topping 17 leaves were left on the plants, that is two less than in 1946. From mid-March onwards the leaves were distinctly yellowish green, whereas on the silt loam at this time the plants still looked dark green. By March the percentages of dry matter in corresponding separates were similar for the two seasons under discussion, but for the last sample on 27th March, 1947, the laterals and stalks showed lowered contents of dry matter, due possibly to the rains of 21st-24th March amounting to 2.18 in. The plants carried the maximum amount of leafage for the season at the sampling on 24th February, that is, at the same period in the season as in the previous year, but the maximum amount of dry matter in the whole plants at any one time was not reached until 10th March. Development of dry matter in the stalks appeared to cease after the middle of March. In 1947 only 15 of the 17 leaves left at topping were harvested, thus leaving two leaves with the laterals on the plants at the end of the season. Laterals at this time provided 10.8 g. of dry matter per plant or 191.5 lb. per acre, compared with the unusually high figure of 950.6 lb. at the end of the previous season.

(b) Silt Loam Soil :

Although the early part of the 1945-46 season was generally very dry, the silt loam area on which this experiment was set out was somewhat cold and damp, especially in the early part of the season. Consequently, as seen in Table XIII, the plants did not come away well after planting. Thus at the end of 44 days they contained approximately only half as much dry matter as the medium sand plants on the same date. The percentage of dry matter in the leaves was low but the stalks showed nearly the same figure as those on the lighter soil. On 25th February, 1946, when the first harvest was made, the plants having been topped to 13 leaves on the 20th, the whole plants yielded only 161.4 g. of dry matter per plant, as against 213.4 g. on this date at the Research Station ; moreover, the latter had already had 6 ripe leaves removed. On the silt loam the percentages of dry matter were relatively low in the leaves

TABLE XII. NUTRIENT INTAKE EXPERIMENT 1946-47 SEASON, TOBACCO RESEARCH STATION, MEDIUM SAND SOIL

Yield of Dry Matter and Percentage of Dry Matter

Date of Sampling.	Part of Plant.	Dry Matter per cent.	Dry Matter per plant. gm.	Dry Matter per acre. lb.
3/12/46	Whole	9.89	0.56	7.4
15/1/47	Leaves	13.62	22.64	299.5
	Stalks	8.04	2.17	28.7
	Whole	12.84	24.81	328.2
29/1/47	Leaves	12.02	54.26	717.7
	Stalks	9.54	15.83	209.4
	Whole	11.35	70.09	927.1
6/2/47	Leaves	15.78	88.90	1175.9
	Stalks	8.44	31.63	418.4
	Whole	12.84	120.53	1594.3
11/2/47	3 Ripe leaves	12.31	16.63	220.0
	3 Near ripe leaves	14.65	25.03	331.1
	11 Green leaves	13.59	60.75	803.5
	Toppings	11.73	6.65	88.0
	Stalks	10.47	48.05	635.6
	Whole	12.92	157.11	2078.2
24/2/47	3 Ripe leaves	15.61	28.57	377.9
	3 Near ripe leaves	24.40	41.62	550.5
	8 Green leaves	20.24	51.12	676.2
	Stalks	13.13	62.76	830.1
	Whole	16.96	184.07	2434.7
10/3/47	3 Ripe leaves	19.77	37.81	500.1
	3 Near ripe leaves	21.72	35.19	465.5
	5 Green leaves	23.87	36.42	481.7
	Stalks	15.27	88.68	1173.0
	Whole	18.23	198.10	2620.3
19/3/47	3 Ripe leaves	21.18	32.41	428.7
	3 Near ripe leaves	21.18	22.69	300.1
	2 Green leaves	22.51	10.04	132.8
	Laterals	13.71	3.55	47.0
	Stalks	16.38	92.08	1217.9
	Whole	18.01	160.77	2126.5
27/3/47	3 Ripe leaves	20.02	26.34	348.4
	2 Near ripe leaves	25.18	14.48	191.5
	Laterals	12.04	10.80	142.8
	Stalks	15.69	91.95	1216.2
	Whole	16.60	143.57	1898.9

right throughout the season and especially at the end, following the rains of March and early April. The dry matter percentages for 9th April are low due to the plants not having dried completely after the heavy rain of 6.87 in. on 6th and 7th, followed by showers on 8th and 9th. As at the Research Station laterals constituted a large proportion of the dry matter of the plants at the end of the season. Production of dry matter on this area was much below that on the lighter soil in this season. Harvested leaf corresponded to 103.3 g. per plant as against 179.1 g. at the Research Station; these figures represent yields of 1,366.5 lb. and 2,369.3 lb. per acre.

TABLE XIII. NUTRIENT INTAKE EXPERIMENT 1945-46 SEASON. LIGHT-PHASE SILT-LOAM SOIL
Yield of Dry Matter and Percentage of Dry Matter

Date of Sampling.	Part of Plant.	Dry Matter per cent.	Dry Matter per plant. gm.	Dry Matter per acre. lb.
3/12/45	Whole	24.32	0.98	13.0
16/1/46	Leaves	13.66	17.19	227.4
	Stalks	8.30	1.52	20.1
	Whole	12.98	18.71	247.5
30/1/46	Leaves	16.97	53.81	711.7
	Stalks	9.25	10.12	133.9
	Whole	14.99	63.93	845.6
11/2/46	Leaves	14.78	87.17	1153.0
	Stalks	13.71	41.91	554.3
	Whole	14.41	129.08	1707.3
25/2/46	3 Ripe leaves	19.45	25.95	343.2
	3 Near ripe leaves	18.25	24.76	327.5
	7 Green leaves	22.00	46.81	619.2
	Toppings (20/2/46)	—	4.96	65.6
	Laterals	13.74	2.02	26.7
	Stalks	14.59	56.92	752.9
	Whole	—	161.42	2135.1
12/3/46	3 Ripe leaves	17.27	25.90	342.6
	3 Near ripe leaves	17.05	20.54	271.7
	4 Green leaves	17.66	16.25	214.9
	Laterals	10.98	1.01	13.4
	Stalks	16.20	62.50	826.7
	Whole	16.66	126.20	1669.3
26/3/46	3 Ripe leaves	15.19	25.78	341.0
	4 Near ripe leaves	15.07	20.09	265.7
	Laterals	9.60	33.55	443.8
	Stalks	15.00	61.11	808.3
	Whole	13.26	140.53	1858.8
9/4/46	4 Leaves	16.12	25.68	339.7
	Laterals	12.11	88.79	1174.4
	Stalks	17.24	83.01	1098.0
	Whole	14.38	197.48	2612.1

The month before planting and the month immediately after planting in the 1946-47 season were unusually dry, and the plants, set out on the same small field that was used for the experiment on the silt loam in the previous season, did not come away at all well. As will be seen by comparison of the yield data in Table XIV with those for corresponding dates in Table XIII, the development of dry matter was very slow, although by the time the first harvest was made on 10th March, 1947, the plants were larger than were those of the previous year on 25th February, 1946, when the first harvest of the 1945-46 season was taken. It will be noticed too that the plants were topped very high, 21 leaves being left on the plants. Percentages of dry matter were low during the earlier part of the season in 1947 but by the end of the season in April the percentages of dry matter were generally similar to corresponding

separates at the end of the previous season. The plants carried the maximum amount of dry matter for the season at the sampling of 10th March, 1947, with a total of 183.3 g., corresponding to 2,424.0 lb. per acre. Yield of harvested leaves was 117.6 g. per plant, or 1,555.0 lb. per acre, these figures being approximately 14 per cent. higher than those of the previous season. It is of interest, too, to note that the stalks of the plants were appreciably larger in 1946-47.

TABLE XIV. NUTRIENT INTAKE EXPERIMENT 1946-47 SEASON, LIGHT-PHASE SILT-LOAM SOIL

Yield of Dry Matter and Percentage of Dry Matter

Date of Sampling.	Part of Plant.	Dry Matter per cent.	Dry Matter per plant. gm.	Dry Matter per acre. lb.
3/12/46	Whole	9.89	0.56	7.4
29/1/47	Leaves	13.20	16.06	212.4
	Stalks	11.24	1.91	25.3
	Whole	12.96	17.97	237.7
11/2/47	Leaves	15.34	46.79	618.9
	Stalks	9.16	8.95	118.4
	Whole	13.84	55.74	737.3
24/2/47	Leaves	14.12	77.23	1021.5
	Stalks	8.47	20.83	275.5
	Whole	12.36	98.06	1297.0
10/3/47	3-4 Ripe leaves lugs	13.92	15.68	207.4
	3 Near ripe leaves	15.77	22.23	294.0
	15 Green leaves	17.52	78.90	1043.6
	Stalks	12.43	56.19	743.2
	Toppings	13.77	10.27	135.8
	Whole	14.91	183.27	2424.0
27/3/47	3 Ripe leaves	14.23	23.23	307.3
	3 Near ripe leaves	15.79	24.43	323.1
	12 Green leaves	17.98	63.81	844.0
	Laterals	11.05	2.32	30.7
	Stalks	14.28	66.62	881.2
	Whole	15.55	180.41	2386.3
2/4/47	3 Ripe leaves	15.17	25.56	338.1
	3 Near ripe leaves	15.05	20.62	272.7
	9 Green leaves	15.92	38.07	503.5
	Stalks	14.30	79.51	1051.7
	Whole	14.88	163.76	2166.0
9/4/47	3 Ripe leaves	17.34	28.71	379.7
	3 Near ripe leaves	16.26	25.15	332.7
	6 Green leaves	17.32	31.50	416.7
	Laterals	12.01	2.27	30.0
	Stalks	15.44	85.05	1125.0
	Whole	16.11	172.68	2284.1
16/4/47	3 Ripe leaves	16.64	24.38	322.5
	3 Near ripe leaves	16.52	19.16	253.4
	3 Green leaves	17.00	11.71	154.9
	Laterals	10.96	4.78	632.2
	Stalks	16.60	107.04	1415.8
	Whole	16.38	167.07	2209.8

TABLE XV. CHEMICAL COMPOSITION OF TOBACCO, NUTRIENT INTAKE EXPERIMENT, TOBACCO RESEARCH STATION 1945-46 SEASON

Expressed as percentage on sand-free dry matter basis

Date of Sampling.	Part of Plant.	In-soluble Ash.	Solu-ble Ash.	Lime CaO.	Mag-nesia MgO.	Phos-phoric Acid P_2O_5.	Potash K_2O.	Total Nitro-gen N.
3/12/45	Whole	0.35	9.99	1.76	0.39	0.62	4.06	1.43
16/1/46	Leaves	1.23	16.05	3.33	0.81	0.72	4.96	3.16
	Stalks	0.53	14.90	1.52	0.55	0.77	6.75	2.41
23/1/46	Leaves	0.17	15.98	3.71	0.84	0.77	4.72	3.34
	Stalks	0.11	14.79	1.70	0.51	0.68	6.66	2.17
30/1/46	Leaves	0.34	12.66	3.05	0.66	0.54	4.01	2.57
	Stalks	0.70	11.61	1.28	0.40	0.50	5.42	1.65
6/2/46	Leaves	0.57	11.63	2.85	0.58	0.48	3.73	2.28
	Stalks	0.11	10.32	1.02	0.35	0.49	4.48	1.36
11/2/46	3 Ripe leaves	0.19	14.84	4.72	0.88	0.35	3.16	1.32
	3 Near ripe leaves	0.17	10.68	2.71	0.56	0.35	3.05	1.75
	Green leaves	0.13	9.11	1.79	0.48	0.44	3.31	2.35
	Stalks and flower heads	0.16	9.57	1.08	0.36	0.44	4.28	1.43
18/2/46	3 Ripe leaves	0.30	13.79	4.35	0.91	0.38	3.04	1.66
	3 Near ripe leaves	0.43	10.72	2.10	0.59	0.42	3.07	2.00
	10 Green leaves	0.17	9.05	2.77	0.57	0.46	2.98	2.41
	Toppings (13/2/46)	0.53	10.84	1.07	0.63	0.99	4.43	4.04
	Stalks	0.13	8.14	0.98	0.35	0.38	3.64	1.35
25/2/46	3 Ripe leaves	0.15	10.62	3.73	0.63	0.45	2.74	1.73
	3 Near ripe leaves	0.28	9.89	2.75	0.65	0.43	3.05	1.87
	7 Green leaves	0.04	8.88	2.20	0.59	0.51	2.74	2.40
	Laterals	0.60	12.92	1.41	0.68	1.41	5.75	4.82
	Stalks	0.08	8.96	1.05	0.41	0.45	3.98	1.48
5/3/46	3 Ripe leaves	0.51	10.41	2.83	0.65	0.44	2.54	1.63
	3 Near ripe leaves	0.35	8.79	2.34	0.60	0.56	2.68	1.86
	5 Green leaves	0.38	8.94	2.34	0.64	0.44	2.52	2.12
	Laterals	0.89	12.78	1.50	0.84	1.14	5.81	3.74
	Stalks	0.20	7.75	1.09	0.35	0.36	3.46	1.12
12/3/46	3 Ripe leaves	0.40	9.21	2.61	0.61	0.45	2.35	1.61
	3 Near ripe leaves	0.15	9.06	2.54	0.65	0.47	2.29	1.92
	2 Green leaves	0.14	9.34	2.58	0.69	0.46	2.31	2.12
	Laterals	0.02	13.51	1.70	0.74	1.05	5.60	3.45
	Stalks	0.18	8.54	1.19	0.37	0.38	3.58	0.99
26/3/46	5 Ripe leaves	0.15	11.05	3.35	0.84	0.61	2.47	2.00
	Laterals	0.06	11.19	1.75	0.62	0.74	4.59	2.46
	Stalks	0.01	6.78	0.92	0.21	0.32	2.88	0.87

Chemical Composition of Plant Separates:

Chemical data for plant separates from the Tobacco Research Station are set out in Tables XV and XVI, the former referring to the 1945-46 season and the latter to the 1946-47 season. Seedlings when set in the field were especially rich in potash, but not in respect of the other constituents determined when comparison is made with later samples. In 1946-47 the seedlings were appreciably richer in all constituents than in 1945-46. As the plants developed the leaves became relatively rich in soluble ash, lime, magnesia, phosphoric acid, potash and nitrogen until about the end of January when all commenced to fall in concentration. When harvesting began on 11th February, in each season the ripe leaves were well supplied with soluble ash, lime and magnesia but were lower in

TABLE XVI. CHEMICAL COMPOSITION OF TOBACCO, NUTRIENT INTAKE EXPERIMENT, TOBACCO RESEARCH STATION 1946-47 SEASON
Expressed as percentage on sand-free dry matter basis

Date of Sampling.	Part of Plant.	Insoluble Ash.	Soluble Ash.	Lime CaO.	Magnesia MgO.	Phosphoric Acid P_2O_5.	Potash K_2O.	Total Nitrogen N.
3/12/46	Whole	0.90	14.13	2.75	0.59	0.75	4.76	2.49
15/1/47	Leaves	0.34	15.72	3.24	0.65	0.61	5.17	2.18
	Stalks	0.42	15.80	1.54	0.50	0.75	7.40	2.30
29/1/47	Leaves	0.26	17.63	4.02	0.95	0.75	5.54	3.55
	Stalks	0.10	12.53	1.18	0.43	0.67	6.00	2.46
6/2/47	Leaves	0.36	15.04	3.45	0.71	0.60	4.40	2.82
	Stalks	0.10	12.07	1.22	0.41	0.69	5.60	2.07
11/2/47	3 Ripe leaves	0.43	20.70	6.71	1.33	0.41	3.58	1.78
	3 Near ripe leaves	0.16	14.45	4.13	0.84	0.47	4.28	2.32
	11 Green leaves	0.20	10.79	2.36	0.57	0.61	4.82	2.98
	Toppings	0.42	10.57	0.95	0.64	1.38	4.51	4.50
	Stalks	0.19	10.03	1.06	0.35	0.52	4.67	1.67
24/2/47	3 Ripe leaves	0.41	13.08	3.78	0.78	0.45	3.32	1.59
	3 Near ripe leaves	0.36	9.58	2.40	0.53	0.41	3.13	1.60
	8 Green leaves	0.26	8.51	1.75	0.49	0.50	3.18	2.23
	Stalks	0.13	9.46	1.22	0.40	0.47	4.06	1.43
10/3/47	3 Ripe leaves	0.48	9.34	2.57	0.56	0.48	2.92	1.17
	3 Near ripe leaves	0.23	8.28	1.94	0.46	0.46	2.77	1.37
	5 Green leaves	0.29	7.87	1.79	0.51	0.44	2.69	1.67
	Stalks	0.09	8.27	1.12	0.37	0.48	3.68	1.25
19/3/47	3 Ripe leaves	0.29	8.99	2.31	0.59	0.53	2.70	1.56
	3 Near ripe leaves	0.22	8.51	2.09	0.61	0.47	2.60	1.84
	2 Green leaves	0.23	8.18	2.08	0.61	0.50	2.37	2.16
	Laterals	1.23	11.53	1.27	0.71	1.04	4.61	3.70
	Stalks	0.02	8.29	1.19	0.42	0.45	3.62	1.25
27/3/47	3 Ripe leaves	0.08	9.86	2.75	0.74	0.59	2.40	2.00
	2 Near ripe leaves	0.10	9.90	2.82	0.76	0.62	2.35	2.30
	Laterals	0.54	14.85	1.53	0.89	1.12	5.22	3.74
	Stalks	0.04	8.52	1.23	0.40	0.41	3.34	1.28

potash and nitrogen than the remaining leaves. There was a tendency from then onwards for soluble ash, lime, potash and nitrogen to decrease in the leaves, while magnesia and phosphoric acid moved towards relatively constant values until the end of the season, when they increased in company with most of the other constituents.

Taking now the changes in leaf composition due to maturation, that is, in passing from the " nearly ripe " to the " ripe"' condition, it is seen that in both seasons potash and nitrogen decreased as the leaf ripened, soluble ash and lime increased, while in general magnesia and phosphoric acid remained fairly constant.

Changes in chemical composition of the stalks are noticeable. Soluble ash and potash, and to some extent nitrogen contents decrease steadily throughout the season, but lime, magnesia and phosphoric acid contents by early February have fallen to values which remain fairly constant throughout the remainder of the season.

The plants of the 1946-47 season began with a greater concentration of nutrients in their dry matter than those of the 1945-46 season. This advantage was maintained by the leaves in general only until the end of February or early in March ; from then onwards they showed lower values than the corresponding separates of the 1945-46 season. On the other hand the stalks were generally richer in all constituents in 1946-47 at corresponding periods throughout the season. Young growth (laterals) was very rich, in comparison with older leaves on the plants, in all constituents determined, with the exception of lime. Potash and nitrogen contents were particularly high.

In Tables XVII and XVIII are set out the chemical data obtained on material from the 1945-46 and 1946-47 seasons' experiments on the silt loam soil. The variations in composition follow in general those shown by the Research Station data. It is notable however that soluble ash, lime, magnesia, potash and nitrogen contents were often appreciably higher in the samples from the silt loam than in those from the medium sand of the Research Station. On the other hand phosphoric acid was lower on the heavier soil. This was particularly marked in the 1946-47 season (Table XVIII). The ripe leaves on the silt loam area were distinguished by their high soluble ash and lime contents, these being at maximum values in the bottom leaves, the former rising to 24.51 per cent. and the latter constituent to 7.49 per cent. CaO. In the previous season the figures were 15.02 per cent. and 4.76 per cent. respectively. Potash was high in these leaves, being 5.76 per cent. K_2O. Young laterals harvested on 27th March, 1947, showed 4.97 per cent. K_2O and 6.01 per cent. N, on the dry basis ; even at the end of the season the much heavier growth on 16th April gave 5.55 per cent. and 5.11 per cent. respectively for these constituents. These figures were much higher than were obtained for laterals in the 1945-46 season. While potash in the corresponding material from the Research Station in 1946-47 approached these values the percentage of nitrogen was much lower. Stalks of plants grown on the heavier soil were richer in nutrients in both seasons than were those on the medium sand, this difference being particularly marked in respect of the nitrogen contents.

TABLE XVII. CHEMICAL COMPOSITION OF TOBACCO, NUTRIENT INTAKE EXPERIMENT, LIGHT-PHASE SILT-LOAM SOIL, 1945 46 SEASON

Expressed as percentage on sand-free dry matter basis

Date of Sampling.	Part of Plant.	Insoluble Ash.	Soluble Ash.	Lime CaO.	Magnesia MgO.	Phosphoric Acid P_2O_5.	Potash K_2O.	Total Nitrogen N.
3/12/45	Whole	0.35	9.99	1.76	0.39	0.62	4.06	1.43
16/1/46	Leaves	0.39	16.25	3.36	0.85	0.61	5.42	3.91
	Stalks	0.38	15.60	1.38	0.54	0.74	7.11	3.35
30/1/46	Leaves	0.14	13.59	3.30	0.76	0.42	4.54	3.20
	Stalks	0.09	13.16	1.48	0.50	0.45	6.06	2.21
11/2/46	Leaves	0.09	13.52	3.59	0.87	0.40	3.61	2.79
	Stalks and flower heads	0.29	10.54	1.16	0.39	0.33	4.46	1.66
25/2/46	3 Ripe leaves	0.43	15.02	4.76	1.06	0.38	3.07	1.93
	3 Near ripe leaves	0.16	12.19	3.44	0.91	0.38	3.08	2.58
	7 Green leaves	0.22	9.83	2.62	0.78	0.43	2.55	3.00
	Toppings (20/2/46)	0.45	11.77	1.06	0.63	1.22	4.57	4.45
	Laterals	0.40	11.84	1.62	0.74	1.44	4.66	2.77
	Stalks	0.22	8.44	1.09	0.40	0.41	3.75	1.31
12/3/46	3 Ripe leaves	0.01	13.78	4.01	1.08	0.52	2.77	3.18
	3 Near ripe leaves	0.06	12.29	3.87	1.09	0.54	2.63	3.61
	4 Green leaves	0.03	12.85	3.49	1.05	0.51	2.76	4.39
	Laterals	0.79	15.28	2.53	0.88	1.27	5.15	5.04
	Stalks	0.10	10.51	1.43	0.50	0.38	3.82	1.61
26/3/46	3 Ripe leaves	0.18	16.29	5.17	1.27	0.50	3.20	3.26
	4 Near ripe leaves	0.16	15.66	4.79	1.30	0.54	3.06	3.56
	Laterals	0.32	14.79	2.43	0.89	0.99	5.41	4.36
	Stalks	0.22	8.88	1.36	0.46	0.31	3.64	1.56
9/4/46	4 Leaves	0.21	16.10	5.30	1.33	0.56	2.47	3.12
	Laterals	0.19	12.58	2.12	0.72	0.80	3.96	3.31
	Stalks	0.14	7.75	1.19	0.36	0.30	3.23	1.28

TABLE XVIII. CHEMICAL COMPOSITION OF TOBACCO, NUTRIENT INTAKE EXPERIMENT, LIGHT-PHASE SILT-LOAM SOIL, 1946-47 SEASON

Expressed as percentage on sand-free dry matter basis

Date of Sampling.	Part of Plant.	Insoluble Ash.	Soluble Ash.	Lime CaO.	Magnesia MgO.	Phosphoric Acid P_2O_5.	Potash K_2O.	Total Nitrogen N.
3/12/46	Whole	0.90	14.13	2.75	0.59	0.75	4.76	2.49
29/1/47	Leaves	0.29	18.70	4.13	0.98	0.54	6.25	4.23
	Stalks	0.14	14.08	1.50	0.43	—	6.45	3.01
11/2/47	Leaves	0.30	16.42	3.95	0.97	0.41	5.11	3.58
	Stalks	0.15	14.07	1.36	0.51	0.45	6.41	2.92
24/2/47	Leaves	0.18	17.02	4.09	1.00	0.45	5.27	3.61
	Stalks	0.25	13.20	1.31	0.50	0.38	6.59	2.90
10/3/47	3-4 Ripe leaves lugs	0.25	24.51	7.49	1.65	0.25	5.76	2.09
	3 Near ripe leaves	0.25	17.09	4.98	1.19	0.30	4.39	2.77
	15 Green leaves	0.11	11.64	2.80	0.78	0.40	3.78	3.47
	Stalks	0.13	9.57	1.01	0.39	0.32	4.20	1.98
	Toppings	0.27	9.78	1.04	0.58	1.11	4.26	4.38
27/3/47	3 Ripe leaves	0.56	17.10	5.38	1.33	0.28	3.85	2.23
	3 Near ripe leaves	0.43	13.15	3.67	0.99	0.31	3.47	2.58
	12 Green leaves	0.31	10.62	2.69	0.83	0.38	3.11	3.24
	Laterals	0.11	13.10	1.44	0.75	1.67	4.97	6.01
	Stalks	0.05	8.55	1.08	0.43	0.27	3.46	1.61
2/4/47	3 Ripe leaves	0.50	15.54	4.59	1.19	0.43	3.55	2.78
	3 Near ripe leaves	0.53	13.75	3.80	1.02	0.47	3.64	3.13
	9 Green leaves	0.57	12.72	3.37	0.98	0.58	3.20	3.70
	Stalks	0.06	9.66	1.51	0.45	0.29	3.59	3.63
9/4/47	3 Ripe leaves	0.84	14.88	4.71	1.21	0.51	3.13	3.05
	2 Near ripe leaves	0.46	13.19	3.85	1.05	0.54	3.03	2.18
	6 Green leaves	0.37	12.10	3.34	0.97	0.59	2.75	3.69
	Laterals	0.31	13.17	1.45	0.75	1.24	5.27	4.77
	Stalks	0.03	8.93	1.23	0.44	0.42	3.36	1.79
16/4/47	3 Ripe leaves	0.79	12.72	3.92	1.14	0.58	2.78	4.63
	3 Near ripe leaves	0.46	13.67	3.82	1.19	0.60	2.78	3.70
	3 Green leaves	0.74	13.68	4.16	1.28	0.67	2.94	4.18
	Laterals	0.40	13.17	1.60	0.75	1.26	5.55	5.11
	Stalks	0.00	8.61	1.33	0.50	0.36	3.19	1.69

TABLE XIX. INTAKE OF NUTRIENTS ON PER PLANT BASIS, 1945-46 SEASON, TOBACCO RESEARCH STATION (MEDIUM SAND SOIL)
Expressed in grams on sand-free dry matter basis

Date of Sampling.	Part of Plant.	Insoluble Ash.	Soluble Ash.	Lime CaO.	Magnesia MgO.	Phosphoric Acid P_2O_5.	Potash K_2O.	Total Nitrogen N.
3 12 45	Whole	0.003	0.10	0.02	0.004	0.006	0.04	0.014
16 1 46	Leaves	0.37	4.78	0.99	0.24	0.21	1.48	0.94
	Stalks	0.02	0.67	0.07	0.02	0.03	0.31	0.11
	Whole	0.39	5.45	1.06	0.26	0.24	1.79	1.05
23 1 46	Leaves	0.09	8.40	1.95	0.44	0.37	2.48	1.76
	Stalks	0.01	1.64	0.19	0.06	0.08	0.74	0.24
	Whole	0.10	10.04	2.14	0.50	0.45	3.22	2.00
30 1 46	Leaves	0.27	10.29	2.48	0.54	0.44	3.26	2.09
	Stalks	0.16	2.61	0.29	0.09	0.11	1.22	0.37
	Whole	0.43	12.90	2.77	0.63	0.55	4.48	2.46
6 2 46	Leaves	0.53	10.78	2.64	0.54	0.45	3.46	2.11
	Stalks	0.05	4.79	0.47	0.16	0.23	2.07	0.63
	Whole	0.58	15.57	3.11	0.70	0.68	5.53	2.74
11/2/46	3 Ripe leaves	0.04	3.05	0.97	0.18	0.07	0.65	0.27
	3 Near ripe leaves	0.05	3.18	0.81	1.67	1.04	0.91	0.52
	Green leaves	0.09	5.97	1.17	0.31	0.29	2.17	1.54
	Stalks and flower heads	0.11	6.66	0.75	0.25	0.31	2.98	1.00
	Whole	0.29	18.86	3.70	2.41	1.71	6.71	3.33
18/2/46	3 Ripe leaves	0.08	3.53	1.11	0.23	0.10	0.78	0.42
	3 Near ripe leaves	0.14	3.47	0.68	0.19	0.14	0.99	0.65
	10 Green leaves	0.10	5.17	1.58	0.33	0.26	1.70	1.38
	Toppings (13/2/46)	0.06	1.15	0.11	0.07	0.10	0.47	0.43
	Stalks	0.09	5.51	0.66	0.24	0.26	2.47	0.91
	Whole	0.47	18.83	4.14	1.06	0.86	6.41	3.79
25/2/46	3 Ripe leaves	0.06	4.56	1.60	0.27	0.19	1.18	0.74
	3 Near ripe leaves	0.11	3.95	1.10	0.26	0.17	1.22	0.75
	7 Green leaves	0.01	3.34	0.83	0.22	0.19	1.03	0.90
	Laterals	0.04	0.79	0.09	0.04	0.09	0.35	0.29
	Stalks	0.07	7.78	0.91	0.36	0.39	3.46	1.29
	Whole	0.29	20.42	4.53	1.15	1.03	7.24	3.97
5/3/46	2 Ripe leaves	0.12	2.46	0.67	0.15	0.10	0.60	0.39
	3 Near ripe leaves	0.10	2.58	0.69	0.18	0.14	0.79	0.55
	2 Green leaves	0.14	3.22	0.84	0.23	0.16	0.91	0.76
	Laterals	0.10	1.47	0.17	0.10	0.13	0.67	0.43
	Stalks	0.15	5.68	0.80	0.26	0.26	2.54	0.82
	Whole	0.61	15.41	3.17	0.92	0.79	5.51	2.95
12/3/46	3 Ripe leaves	0.13	3.01	0.85	0.20	0.15	0.77	0.53
	3 Near ripe leaves	0.04	2.32	0.65	0.17	0.12	0.59	0.49
	2 Green leaves	0.02	1.23	0.34	0.09	0.06	0.30	0.28
	Laterals	0.00	2.80	0.35	0.15	0.22	1.16	0.72
	Stalks	0.16	7.41	1.03	0.32	0.33	3.10	0.86
	Whole	0.35	16.77	3.22	0.93	0.88	5.92	2.88
26/3/46	5 Ripe leaves	0.05	3.73	1.13	0.28	0.21	0.83	0.67
	Laterals	0.04	8.04	1.26	0.45	0.53	3.30	1.77
	Stalks	0.01	8.21	1.11	0.25	0.39	3.49	1.05
	Whole	0.10	19.98	3.50	0.98	1.13	7.62	3.49

TABLE XX. INTAKE OF NUTRIENTS ON PER PLANT BASIS, 1946-47 SEASON, TOBACCO RESEARCH STATION (MEDIUM SAND SOIL)
Expressed in grams on sand-free dry matter basis

Date of Sampling.	Part of Plant.	Insoluble Ash.	Soluble Ash.	Lime CaO.	Magnesia MgO.	Phosphoric Acid P_2O_5.	Potash K_2O.	Total Nitrogen N.
3/12/46	Whole	0.005	0.08	0.02	0.003	0.004	0.03	0.01
15/1/47	Leaves	0.08	3.56	0.73	0.15	0.14	1.17	0.49
	Stalks	0.01	0.34	0.03	0.01	0.02	0.16	0.05
	Whole	0.09	3.90	0.76	0.16	0.16	1.33	0.54
29/1/47	Leaves	0.14	9.57	2.18	0.52	0.41	3.01	1.93
	Stalks	0.02	1.98	0.19	0.07	0.11	0.95	0.39
	Whole	0.16	11.55	2.37	0.59	0.52	3.96	2.32
6/2/47	Leaves	0.32	13.37	3.42	0.63	0.53	3.91	2.51
	Stalks	0.03	3.82	0.39	0.13	0.21	1.77	0.65
	Whole	0.35	17.19	3.81	0.76	0.74	5.68	3.16
11/2/47	3 Ripe leaves	0.07	3.44	1.12	0.22	0.07	0.60	0.30
	3 Near ripe leaves	0.04	3.62	1.03	0.20	0.12	1.07	0.58
	11 Green leaves	0.12	6.55	1.43	0.35	0.37	2.93	1.81
	Toppings	0.03	0.70	0.06	0.04	0.09	0.30	0.30
	Stalks	0.09	4.82	0.51	0.16	0.25	2.24	0.80
	Whole	0.35	19.13	4.15	0.97	0.90	7.14	3.79
24/2/47	3 Ripe leaves	0.12	3.74	1.08	0.22	0.13	0.95	0.45
	3 Near ripe leaves	0.15	3.98	1.00	0.22	0.17	1.30	0.67
	8 Green leaves	0.13	4.35	0.90	0.25	0.26	1.63	1.14
	Stalks	0.08	5.94	0.76	0.25	0.29	2.55	0.90
	Whole	0.48	18.01	3.74	0.94	0.85	6.43	3.16
10/3/47	3 Ripe leaves	0.18	3.53	0.97	0.21	0.18	1.10	0.44
	3 Near ripe leaves	0.08	2.91	0.68	0.16	0.16	0.97	0.48
	5 Green leaves	0.11	2.87	0.65	0.19	0.16	0.97	0.61
	Stalks	0.08	7.33	1.00	0.33	0.43	3.26	1.11
	Whole	0.45	16.64	3.30	0.89	0.93	6.30	2.64
19/3/47	3 Ripe leaves	0.09	2.91	0.74	0.19	0.17	0.88	0.51
	3 Near ripe leaves	0.05	1.93	0.47	0.14	0.11	0.59	0.42
	2 Green leaves	0.02	0.82	0.21	0.06	0.05	0.24	0.22
	Laterals	0.04	0.41	0.05	0.03	0.04	0.16	0.13
	Stalks	0.02	7.63	1.10	0.39	0.42	3.33	1.15
	Whole	0.22	13.70	2.57	0.81	0.79	5.20	2.43
27/3/47	3 Ripe leaves	0.02	2.60	0.72	0.20	0.16	0.63	0.53
	2 Near ripe leaves	0.01	1.43	0.41	0.11	0.09	0.34	0.33
	Laterals	0.06	1.60	0.17	0.10	0.12	0.56	0.40
	Stalks	0.04	7.83	1.13	0.37	0.39	3.07	1.18
	Whole	0.13	13.46	2.43	0.78	0.76	4.60	2.44

Intake of Nutrients :

Calculations on a similar basis to those reported above for the 1944-45 experiments have been made using the data of the 1945-46 and 1946-47 experiments. For the medium sand area the results are given in Table XIX for the 1945-46 season, and in Table XX for the 1946-47 season.

In keeping with the slightly better growth in the 1945-46 season the intake of nutrients was greater in the very early part of the season than in the 1946-47 season, but at the time of the first harvest more soluble ash, lime, potash and nitrogen had been absorbed in the latter season. Absorption of phosphoric acid and magnesia was appreciably greater at this stage in 1945-46. At later periods plants of the 1945-46 season contained a greater weight of nutrients at a given period than those of the next season. Nutrient residues in the plants when harvesting was completed were appreciably greater, especially for potash and nitrogen, in 1945-46; these latter constituents provided an excess of 2.8 g. of K_2O and 0.9 g. of N per plant in favour of the 1945-46 crop.

TABLE XXI. INTAKE OF NUTRIENTS ON PER PLANT BASIS, 1945-46 SEASON, LIGHT-PHASE SILT-LOAM SOIL
Expressed in grams on sand-free dry matter basis

Date of Sampling.	Part of Plant.	Insoluble Ash.	Soluble Ash.	Lime CaO.	Magnesia MgO.	Phosphoric Acid P_2O_5.	Potash K_2O.	Total Nitrogen N.
3/12/45	Whole	0.003	0.10	0.02	0.004	0.006	0.04	0.014
16/1/46	Leaves	0.07	2.79	0.58	0.15	0.10	0.93	0.67
	Stalks	0.006	0.24	0.02	0.01	0.01	0.11	0.05
	Whole	0.076	3.03	0.60	0.16	0.11	1.04	0.72
30/1/46	Leaves	0.08	7.31	1.78	0.41	0.23	2.44	1.72
	Stalks	0.01	1.33	0.15	0.05	0.05	0.61	0.22
	Whole	0.09	8.64	1.93	0.46	0.28	3.05	1.94
11/2/46	Leaves	0.08	11.79	3.13	0.76	0.35	3.15	2.43
	Stalks and flower heads	0.12	4.42	0.49	0.16	0.14	1.87	0.70
	Whole	0.20	16.21	3.62	0.92	0.49	5.02	3.13
25/2/46	3 Ripe leaves	0.11	3.90	1.24	0.28	0.10	0.80	0.56
	3 Near ripe leaves	0.04	3.02	0.85	0.23	0.10	0.76	0.64
	7 Green leaves	0.10	4.60	1.23	0.37	0.20	1.19	1.40
	Toppings (20/2/46)	0.02	0.58	0.05	0.03	0.06	0.23	0.22
	Laterals	0.01	0.24	0.03	0.01	0.03	0.09	0.06
	Stalks	0.13	4.80	0.62	0.23	0.23	2.13	0.75
	Whole	0.41	17.14	4.02	1.15	0.72	5.20	3.57
12/3/46	3 Ripe leaves	0.00	3.57	1.04	0.28	0.13	0.72	0.82
	3 Near ripe leaves	0.01	2.52	0.79	0.22	0.11	0.54	0.74
	4 Green leaves	0.005	2.08	0.57	0.17	0.08	0.44	0.71
	Laterals	0.01	0.15	0.03	0.01	0.01	0.05	0.05
	Stalks	0.06	6.57	0.89	0.31	0.24	2.39	1.01
	Whole	0.085	14.89	3.32	0.99	0.57	4.14	3.33
26/3/46	3 Ripe leaves	0.05	4.20	1.33	0.33	0.13	0.82	0.84
	4 Near ripe leaves	0.03	3.15	0.96	0.26	0.11	0.61	0.72
	Laterals	0.11	4.96	0.82	0.30	0.33	1.82	1.46
	Stalks	0.13	5.43	0.83	0.28	0.19	2.22	0.95
	Whole	0.32	17.74	3.94	1.17	0.76	5.47	3.97
9/4/46	4 Leaves	0.05	4.13	1.36	0.34	0.14	0.63	0.80
	Laterals	0.17	11.17	1.88	0.64	0.71	3.52	2.94
	Stalks	0.12	6.43	0.99	0.30	0.25	2.68	1.06
	Whole	0.34	21.73	4.23	1.28	1.10	6.83	4.80

TABLE XXII. INTAKE OF NUTRIENTS ON PER PLANT BASIS, 1946-47 SEASON, LIGHT-PHASE SILT-LOAM SOIL

Expressed in grams on sand-free dry matter basis

Date of Sampling.	Part of Plant.	Insoluble Ash.	Soluble Ash.	Lime CaO.	Magnesia MgO.	Phosphoric Acid P_2O_5.	Potash K_2O.	Total Nitrogen N.
3/12/46	Whole	0.005	0.08	0.02	0.003	0.004	0.03	0.014
29/1/47	Leaves	0.04	3.00	0.66	0.16	0.09	1.00	0.68
	Stalks	0.003	0.27	0.03	0.01	—	0.12	0.06
	Whole	0.043	3.27	0.69	0.17	0.09	1.12	0.74
11/2/47	Leaves	0.14	7.68	1.85	0.46	0.19	2.39	1.68
	Stalks	0.01	1.26	0.12	0.05	0.04	0.57	0.26
	Whole	0.15	8.94	1.97	0.51	0.23	2.96	1.94
24/2/47	Leaves	0.14	13.14	3.16	0.78	0.35	4.07	2.79
	Stalks	0.05	2.75	0.27	0.10	0.08	1.37	0.60
	Whole	0.19	15.89	3.43	0.88	0.43	5.44	3.39
10/3/47	3-4 Ripe leaves lugs	0.04	3.84	1.17	0.26	0.04	0.90	0.33
	3 Near ripe leaves	0.05	3.80	1.11	0.26	0.07	0.98	0.62
	15 Green leaves	0.09	9.18	2.21	0.62	0.32	2.98	2.74
	Stalks	0.07	5.38	0.57	0.21	0.18	2.36	1.11
	Toppings	0.03	1.00	0.11	0.06	0.11	0.44	0.45
	Whole	0.28	23.20	5.17	1.41	0.72	7.66	5.25
27/3/47	3 Ripe leaves	0.13	3.97	1.25	0.31	0.07	0.89	0.52
	3 Near ripe leaves	0.11	3.21	0.90	0.24	0.08	0.85	0.63
	12 Green leaves	0.20	6.78	1.71	0.52	0.24	1.98	2.07
	Laterals	0.003	0.30	0.03	0.02	0.04	0.12	0.14
	Stalks	0.03	5.70	0.72	0.29	0.18	2.31	1.07
	Whole	0.47	19.96	4.61	1.38	0.61	6.15	4.43
2/4/47	3 Ripe leaves	0.13	3.97	1.17	0.30	0.11	0.91	0.71
	3 Near ripe leaves	0.11	2.84	0.78	0.21	0.10	0.75	0.65
	9 Green leaves	0.22	4.84	1.28	0.37	0.22	1.22	1.41
	Stalks	0.05	7.68	1.20	0.36	0.23	2.85	2.89
	Whole	0.51	19.33	4.43	1.24	0.66	5.73	5.66
9/4/47	3 Ripe leaves	0.24	4.27	1.35	0.35	0.15	0.90	0.88
	3 Near ripe leaves	0.12	3.32	0.97	0.26	0.14	0.76	0.55
	6 Green leaves	0.12	3.81	1.05	0.31	0.19	0.87	1.16
	Laterals	0.01	0.30	0.03	0.02	0.03	0.12	0.11
	Stalks	0.03	7.59	1.05	0.37	0.36	2.86	1.52
	Whole	0.52	19.29	4.45	1.31	0.87	5.51	4.22
16/4/47	3 Ripe leaves	0.19	3.10	0.96	0.28	0.14	0.68	1.13
	3 Near ripe leaves	0.09	2.62	0.73	0.23	0.11	0.53	0.71
	3 Green leaves	0.09	1.60	0.49	0.15	0.08	0.34	0.49
	Laterals	0.02	0.63	0.08	0.04	0.06	0.27	0.24
	Stalks	0.00	9.22	1.43	0.54	0.39	3.41	1.81
	Whole	0.39	17.17	3.69	1.24	0.78	5.23	4.38

Data on a precisely similar basis to that given above for the plants grown at the Research Station have been obtained for the crops on the silt loam area ; these are set out in Tables XXI and XXII. By the time of the first harvest on 25th February, 1946, minerals corresponding to 17.14 g. per plant had been absorbed; of these lime constituted 4.02 g., magnesia 1.15 g., phosphoric acid 0.72 g., potash 5.20 g., K_2O and nitrogen 3.57 g. In the following season, by 24th February somewhat less of all constituents except potash had been taken up by the plant. At the time of the first harvest on 10th March, 1947, larger quantities of all nutrients except phosphoric acid had been absorbed than at the time of the first harvest in 1946. It is interesting to note that the nutrients removed in each harvest of ripe leaves tends to be constant, except for nitrogen, in any one season. The Research Station data however do not fall into line with this statement.

The nutrient data of Tables XIX to XXII have been also calculated to a pounds of nutrient per acre basis using the factor 13.227 for converting grams per plant to pounds per acre, assuming that the rate of planting is 6,000 plants per acre. Data are set out for the whole plant only in order to save space. In Table XXIII the results of these calculations are given for the two crops grown on the medium sand.

TABLE XXIII. NUTRIENT STATUS, EXPRESSED IN POUNDS PER ACRE, OF PLANTS GROWN ON MEDIUM SAND, 1945-46 AND 1946-47

Season.	Date of Sampling.	Soluble Ash lb.	Lime CaO lb.	Magnesia MgO lb.	Phosphoric Acid P_2O_5. lb.	Potash K_2O. lb.	Nitrogen N. lb.
1945-46	3/12/45*	1.3	0.2	0.05	0.08	0.5	0.2
	16/1/46	72.1	14.0	3.4	3.2	23.7	13.9
	23/1/46	132.8	28.3	6.6	6.0	42.6	26.5
	30/1/46	170.6	36.6	8.3	7.3	59.3	32.5
	6/2/46	206.0	41.1	9.3	9.0	73.2	36.2
	11/2/46	249.5	48.9	12.0	10.3	88.8	44.1
	18/2/46	249.1	54.7	14.0	11.4	84.8	50.1
	25/2/46	270.1	59.9	15.2	13.6	95.8	52.5
	5/3/46	203.8	41.9	12.2	10.5	72.9	39.0
	12/3/46	221.8	42.6	12.3	11.6	78.3	38.1
	26/3/46	264.3	46.3	13.0	15.0	100.8	46.2
1946-47	3/12/46*	1.1	0.2	0.05	0.06	0.35	0.18
	15/1/47	51.6	10.1	2.1	2.1	17.6	7.1
	29/1/47	152.8	31.3	7.8	6.8	52.4	30.7
	6/2/47	227.4	50.4	10.0	9.9	75.1	41.9
	11/2/47	253.0	54.9	12.8	11.9	94.4	50.1
	24/2/47	238.2	49.5	12.4	11.2	85.1	41.8
	10/3/47	220.1	43.7	11.8	12.3	83.3	34.9
	19/3/47	181.2	34.0	10.7	10.5	68.8	32.1
	27/3/47	178.0	32.1	10.3	10.1	60.8	32.3

* Date of planting in the field.

These data show that when the plants contained the maximum amount of nutrients, on 25th February, 1946, and 11th February, 1947, these corresponded in both seasons to approximately 55 lb. of superphosphate, 200 lb. of sulphate of potash and 250 lb. of sulphate of ammonia per acre. The total quantity of nutrients absorbed throughout the season can be obtained by combining the data for individual separates at each harvest. This is considered later in conjunction with the changes occurring in nutrient status during the harvesting period.

In Table XXIV are given data for the nutrient status of the plants on the heavier soil for the seasons 1945-46 and 1946-47, expressed in pounds per acre.

TABLE XXIV. NUTRIENT STATUS, EXPRESSED IN POUNDS PER ACRE, OF PLANTS GROWN ON SILT LOAM, 1945-46 AND 1946-47

Season.	Date of Sampling.	Soluble Ash lb.	Lime CaO lb.	Magnesia MgO lb.	Phosphoric Acid P_2O_5 lb.	Potash K_2O lb.	Nitrogen N. lb.
1945-46	3/12/45*	1.3	0.2	0.05	0.08	0.5	0.2
	16/1/46	40.1	7.9	2.1	1.5	13.8	9.5
	30/1/46	114.3	25.5	6.1	3.7	40.3	25.7
	11/2/46	214.4	47.9	12.2	6.5	66.4	41.4
	25/2/46	226.7	53.2	15.2	9.5	68.8	47.2
	12/3/46	196.9	43.9	13.1	7.5	54.8	44.1
	26/3/46	234.7	52.1	15.5	10.0	72.4	52.5
	9/4/46	287.4	56.0	16.9	14.6	90.3	63.5
1946-47	3/12/46*	1.1	0.2	0.05	0.05	0.35	0.2
	29/1/47	43.2	9.1	2.2	1.2†	14.8	9.8
	11/2/47	118.3	26.1	6.8	3.1	39.2	25.7
	24/2/47	210.2	45.4	11.6	5.7	72.0	44.8
	10/3/47	306.9	68.4	18.7	9.5	101.3	69.4
	27/3/47	264.0	61.0	18.3	8.1	81.3	58.6
	2/4/47	255.7	58.6	16.4	8.7	75.8	74.9
	9/4/47	255.2	58.9	17.3	11.5	72.9	55.8
	16/4/47	227.1	48.8	16.4	10.3	69.2	57.9

* Date of planting in the field. † Leaves only.

The data of Table XXIV show the greater amount of nutrients in the plants in the second season as compared with the first at the time of the harvest, the increases per acre being 15.2 lb. of CaO, 3.5 lb. of MgO, 32.5 lb. of K_2O and 22.2 lb. of N ; the same quantity of phosphoric acid was present in both seasons. At all later harvests of the second season, except that on 16th April, there were greater quantities of nutrients in the plants than in the first season. The data for the final harvests show that appreciable quantities of nutrients were available for fertilizing the soil if the plants were disced in or ploughed down after harvesting was completed.

Discussion :

Under Nelson conditions the first harvests are taken from the tobacco plants while they are still growing rapidly. In the present experiments topping has usually been carried out either on the day of the first harvests or at a date very close thereto. The remaining leaves then develop rapidly as also do the stalks. The magnitude of these changes in respect of development of dry matter and of further intake of plant nutrients in the seasons 1945-46 and 1946-47 will now be considered. From the detailed data of tables XI to XIV the increases in dry matter of the whole plant, of all leaves and ripe leaves only, between the periods set out, can be calculated. Data for both soil types and for both experimental seasons are given in Table XXV. Precipitation has also been included.

TABLE XXV. SHOWING DRY MATTER INCREMENTS IN POUNDS PER ACRE BETWEEN THE STATED PERIODS

Soil type.	Period.	Rainfall in.	Increment of dry matter for whole plant lb.	Increment of dry matter for all leaves lb.	Increment of dry matter for ripe leaves lb.
Medium Sand	11/2/46-18/2/46	0.49	375.9	261.2	—55.6
	18/2/46-25/2/46	0.00	743.2	409.7	139.7
	25/2/46- 5/3/46	1.25	45.1	152.6	—59.2
	5/3/46-12/3/46	1.06	380.0	80.7	44.2
	12/3/46-26/3/46	0.91	1064.2	67.1	67.1
	Totals	3.71	2608.4	971.3	—
Silt Loam	25/2/46-12/3/46	2.31	—57.0	—117.5	15.1
	12/3/46-26/3/46	0.91	532.1	120.1	69.3
	26/3/46- 9/4/46	8.09	1094.3	74.0	74.0
	Totals	11.31	1559.4	76.6	—
Medium Sand	11/2/47-24/2/47	1.90	664.5	470.0	46.8
	24/2/47-10/3/47	0.00	563.5	220.6	—50.4
	10/3/47-19/3/47	0.00	6.3	—85.6	—36.8
	19/3/47-27/3/47	2.19	201.1	107.0	48.3
	Totals	4.09	1435.4	712.0	—
Silt Loam	10/3/47-27/3/47	2.19	305.5	136.8	13.3
	27/3/47- 2/4/47	0.00	187.0	—52.8	15.0
	2/4/47- 9/4/47	1.00	456.2	353.9	107.0
	9/4/47-16/4/47	4.53	305.4	—18.6	—10.2
	Totals	7.72	1254.1	419.3	—

Note : The medium sand was irrigated on 15th and 30th January, 1946, and on 29th January, 1947, water equivalent to approximately one inch of rainfall being applied on each occasion. The silt loam was not irrigated in either season.

The data of Table XXV have been given in pounds of dry matter per acre rather than as grams per plant. It is clear that very large increments of dry matter occurred at certain periods in both seasons, especially just after harvesting began, because the plants were still in an actively growing condition, and at the end of the season when rains after periods of dry weather caused the development of large amounts of lateral growth, particularly in 1946. Growth can be correlated to some extent with the rainfall ; a dry period causes a depression in growth, especially it would appear, in the ripening leaf as distinct from young leaves and the stalks. However, the effect is delayed and reduction in growth was seen only after a week or two of dry weather. Response to rainfall

appeared to be more rapid. Increase in weight of " nearly ripe " leaves to the " ripe " condition appeared to be irregular, especially at the Research Station, where the effects of dry weather on the plants were likely to be more severe than on the heavier soil. This resulted also in much more rapid ripening of the leaf at the Station and thus the harvesting was completed before the end of March, whereas on the heavier soil harvesting continued until about the middle of April. It is interesting to compare the total dry matter production and the weight of harvested leaf for the crops discussed in Table XXV. The requisite data are set out below, expressed in pounds of dry matter per acre.

Soil Type.	Season.	Dry Matter when harvesting began lb.	Dry Matter Increment during harvesting lb.	Total Dry Matter for Season lb.	Ripe leaves harvested lb.
Medium sand	1945-46	2453.2	2608.4	5061.6	2369.3
	1946-47	2078.2	1435.4	3513.6	1875.1
Silt loam	1945-46	2135.1	1559.4	3694.5	1366.5
	1946-47	2424.0	1254.1	3678.1	1555.0

Owing to the damp conditions on the silt loam soil the plants did not grow as well as they would on a better situated field of this type. The data therefore do not show what this soil is really capable of producing. On the present figures the yield was much below that of the medium sand ; on the latter an average of 50 per cent. of the dry matter production was taken in ripe leaves, but on the heavier soil only 40 per cent. of the dry matter was harvested. The yields obtained on the heavier soil in the 1944-45 season were probably more truly characteristic of the producing capacity of this soil type.

In a similar procedure to that used with the data for production of dry matter the figures for intake of nutrients can be assembled to show the variations during the periods intervening between successive harvests. They may be set out to show the intake by the whole plants or to show the changes in the nutrient status of leaves in passing from the " nearly ripe " to the " ripe " condition. It may be said at once that except for soluble ash and lime, the latter changes were small in most cases, and judging by the negative figure often obtained, especially after a dry period, there may even have been loss of nutrients from the ripe leaves ; dry matter production when showing a negative value was not always accompanied by an apparent loss of nutrients, while in other cases an apparent increase in dry matter production seemed to be accompanied by a loss of nutrients. To what extent the summation of experimental errors in chemical analysis and in determining dry matter production affects these small differences in nutrient status cannot be stated.

To return now to consideration of the changes in nutrient status of the whole plants during harvesting ; data to give a view of the position are set out in Table XXVI

TABLE XXVI. SHOWING CHANGES IN STATUS OF WHOLE PLANTS IN POUNDS PER ACRE OF NUTRIENT BETWEEN THE STATED PERIODS FOR THE SEASONS 1945-46 AND 1946-47

Soil Type.	Period.	Rainfall in.	Soluble Ash lb.	Lime CaO lb.	Magnesia MgO lb.	Phosphoric Acid P_2O_5 lb.	Potash K_2O lb.	Nitrogen N lb.
Medium Sand	11/2/46-18/2/46	0.49	40.0	18.6	4.4	2.1	4.6	9.6
	18/2/46-25/2/46	0.00	83.0	21.3	5.2	4.9	27.5	13.6
	25/2/46- 5/3/46	1.25	−6.0	3.1	0.2	−0.7	−7.2	−3.7
	5/3/46-12/3/46	1.06	50.5	9.5	2.1	2.5	13.3	4.2
	12/3/46-26/3/46	0.91	82.3	15.0	3.3	5.5	32.7	15.1
	Totals	3.71	249.8	67.5	15.2	14.3	70.9	38.8
Silt Loam	25/2/46-12/3/46	2.31	29.5	7.8	2.0	0.1	2.6	6.3
	12/3/46-26/3/46	0.91	84.9	22.0	6.1	4.2	27.1	19.3
	26/3/46- 9/4/46	8.09	108.3	21.5	5.8	6.2	28.8	22.1
	Totals	11.31	222.7	51.3	13.9	10.5	58.5	47.7
Medium Sand	11/2/47-24/2/47	1.90	39.9	10.5	3.1	1.4	2.5	−0.5
	24/2/47-10/3/47	0.00	31.4	8.4	2.2	2.7	10.8	−0.9
	10/3/47-19/3/47	0.00	7.8	3.2	1.7	0.5	0.0	3.0
	19/3/47-27/3/47	2.19	35.3	8.0	2.1	1.9	3.7	6.9
	Totals	4.09	114.4	30.1	9.1	6.5	17.0	8.5
Silt Loam	10/3/47-27/3/47	2.19	20.2	9.6	3.8	0.6	2.3	0.5
	27/3/47- 2/4/47	0.00	44.2	14.2	2.2	1.5	6.2	23.2
	2/4/47- 9/4/47	1.00	51.9	15.8	4.9	4.2	9.2	−9.7
	9/4/47-16/4/47	4.53	28.4	7.8	3.6	0.8	8.2	13.7
	Totals	7.72	144.7	47.4	14.5	7.1	21.3	26.7

The numerical data of Table XXVI demonstrate clearly that absorption of nutrients continued right up to the end of the season. Although the amounts of soluble ash, lime, potash and nitrogen were appreciable the absorption of magnesia and phosphoric acid was much less, but nevertheless formed an important part of the seasons' totals. As was noted in the discussion on the effect of weather conditions on the production of dry matter, dry and less dry periods were associated with small intakes, or even negative values, and substantial intakes of nutrients respectively. The large positive followed by negative, values for the second and third entries of 1946 on the medium sand are possibly due to abnormally large plants having been selected for samples on 25th February ; the dry matter figures for leaves on this date appear to be unusually high.

Combining the totals of Table XXVI with the total intake of nutrients as at the first harvest the following data, expressed to the nearest pound per acre, are obtained :

Location.	Season.	Soluble Ash lb.	Lime CaO lb.	Magnesia MgO lb.	Phosphoric Acid P_2O_5 lb.	Potash K_2O lb.	Nitrogen N. lb.
Medium Sand	1945-46	499	116	27	25	160	83
	1946-47	367	85	22	18	111	59
Silt Loam	1945-46	449	104	29	20	127	95
	1946-47	452	116	33	17	123	96

On the medium sand only about two-thirds as much of the nutrients was absorbed by the plants in 1946-47 as in 1945-46, but on the silt loam the amounts were similar in both seasons. In 1945-46 the quantities

Table XXVII. - Chemical Composition of Cured Leaf from Successive Harvests, Tobacco Research Station, 1945-46 Season

Constituents expressed as percentage on sand-free dry matter basis

Date of Sampling.	Soluble Ash.	Insoluble Ash.	Lime CaO.	Magnesia MgO.	Phosphoric Acid P_2O_5.	Potash K_2O.	Total Nitrogen N.	Glucose.	Fructose.	Sucrose.	Total Sugars.	Ratio, Total Sugars:Total Nitrogen.
Blades												
12/2/46	13.07	0.54	4.88	0.91	0.37	2.03	1.59	16.84	7.07	2.59	26.50	16.7
18/2/46	11.83	0.36	4.54	0.80	0.39	2.03	1.59	16.32	6.29	4.24	26.85	16.9
26/2/46	8.89	0.25	3.12	0.67	0.40	1.76	1.88	21.45	6.53	2.00	29.98	15.9
5/3/46	12.04	0.12	4.30	0.93	0.70	1.36	3.05	14.92	0.82	0.20	15.94	5.2
13/3/46	8.25	0.09	2.86	0.50	0.44	1.55	1.98	18.16	11.89	2.51	32.56	16.4
3/4/46	10.82	0.30	4.06	0.80	0.57	1.59	1.77	16.36	8.36	2.00	26.72	15.1
Midribs												
12/2/46	21.21	0.34	4.15	1.09	0.60	7.35	1.78	9.95	1.10	0.30	11.35	6.4
18/2/46	19.92	0.20	3.67	0.96	0.51	7.79	1.60	9.93	2.56	1.35	13.84	8.6
26/2/46	18.31	0.13	3.18	0.96	0.52	7.59	1.32	11.58	0.63	2.05	14.26	10.8
5/3/46	18.55	0.11	4.71	1.62	0.88	4.55	2.41	5.57	0.05	0.00	5.62	2.3
13/3/46	16.58	0.08	2.78	0.81	0.59	6.63	1.82	12.91	2.22	1.17	16.30	9.0
3/4/46	18.98	0.05	4.03	1.42	0.76	5.63	2.20	9.19	1.31	1.28	11.78	5.3

absorbed were substantially the same on both soil types, except that rather more potash was present in the plants on the medium sand. From the two sets of data presented above, the proportion of the total season's intake that was absorbed during the harvesting season can be readily determined. It appears that in 1945-46 substantially one-half of each of the constituents estimated by chemical analysis entered the plants during this period. In 1946-47 the proportions of each constituent varied rather more widely. Thus on the medium sand one-third of the soluble ash, lime and phosphoric acid, two-fifths of the magnesia and one-seventh of the potash and nitrogen were taken up by the plants after harvesting began ; on the silt loam one-third of the soluble ash, two-fifths of the lime, magnesia, phosphoric acid and nitrogen, but only one-sixth of the potash, were absorbed over this period.

Samples of cured leaf from the plot on the medium sand were available from the successive harvests of the 1945-46 and 1946-47 seasons. Results of chemical examination of these samples are given in Table XXVII for the former and in Table XXVIII for the latter season. Mineral, nitrogen and sugar contents are reported separately for the blade and the midrib of the leaves.

In the 1945-46 season all the harvests, except that on 5th March, showed high total sugar contents, the maximum figure being 32.56 per cent. The low sugars and high nitrogen content of the sample on 5th March may be connected with effect of the 1.25 in. of rain which fell just before this date, breaking a drought of 7 weeks duration. The high nitrogen and low sugar content has given the low value of 5.2 per cent. for the sugars:nitrogen ratio. (It is to be noted however that the "ripe" leaves of the plant separates on the above date do not show this high nitrogen figure). Soluble ash content of the blades tended to decrease in passing from lower to upper leaves, as did lime, magnesia, phosphoric acid and potash. The latter constituent was low throughout the season. On the other hand nitrogen was appreciably higher in the upper than in the lower leaves. The great distinguishing differences between the blades and the midribs are the high soluble ash and potash contents of the latter ; potash in the midribs was about four times as high as in the blades. Magnesia and phosphoric acid were relatively high in the midribs. Total sugar contents of the midribs were about half those of the corresponding samples of blades ; fructose formed a smaller proportion of the total sugars in midribs than in blades. In general the type of variation shown by the harvests of the 1945-46 season was similar to that reported above for 1944-45.

pH values and ratios of weights of separated blades and midribs are available for this season. They are set out below :

Date of Harvest.	pH value.		Ratio Weight of blade:weight of midrib.
	Blade.	Midrib.	
12/2/46	5.40	4.95	4.0
18/2/46	5.35	4.90	3.7
26/2/46	5.40	5.05	4.5
5/3/46	5.40	5.00	4.2
13/3/46	5.45	4.85	4.0
3/4/46	5.50	5.05	3.4

There does not appear to be any significant variation in the pH values for successive harvests with either the blades or the midribs ; midribs are, however, distinctly more acid in reaction than their corresponding blades. Both separates are acid, the blades giving pH values

Table XXVIII. Chemical Analyses of Cured Leaf from Successive Harvests, Tobacco Research Station, 1946-47 Season

Constituents expressed as percentage on sand-free dry matter basis

Date of Sampling.	Soluble Ash	Insoluble Ash.	Lime CaO.	Magnesia MgO.	Phosphoric Acid P_2O_5.	Potash K_2O.	Total Nitrogen N.	Glucose.	Fructose.	Sucrose.	Total Sugars.	Ratio, Total Sugars : Total Nitrogen.
Blades												
12/2/47	19.90	0.12	3.64	1.35	0.46	2.75	2.23	4.44	4.23	2.11	10.78	4.8
24/2/47	13.77	0.34	4.73	0.84	0.50	3.30	1.98	10.54	8.42	7.06	26.02	13.1
11/3/47	10.32	0.06	3.38	1.35	1.51	2.01	1.96	12.29	9.02	6.09	27.40	14.0
19/3/47	8.90	0.08	2.87	0.59	0.55	1.62	2.05	15.25	10.54	4.22	30.01	14.6
27/3/47	9.15	0.06	2.89	0.64	0.59	1.84	2.37	8.70	6.56	7.87	23.13	9.8
2/4/47	12.01	0.08	3.96	0.90	0.74	2.05	1.63	5.89	5.45	1.58	12.92	7.9
Midribs												
12/2/47	23.39	0.06	4.06	0.86	0.59	8.69	2.62	5.74	2.90	2.22	10.86	4.1
24/2/47	20.61	0.07	3.58	0.62	0.63	7.99	1.87	6.20	0.29	2.86	9.35	5.0
11/3/47	19.02	0.04	2.88	0.81	0.67	7.58	1.46	9.91	4.52	1.31	15.74	10.8
19/3/47	18.81	0.03	3.01	1.02	0.87	7.29	1.51	7.94	5.00	3.19	16.13	10.7
27/3/47	18.69	0.25	3.18	1.13	0.80	6.18	1.68	5.42	3.18	1.90	10.50	6.2
2/4/47	20.09	0.18	2.14	1.47	0.97	6.56	2.06	3.97	nil	1.43	5.40	2.6

of about 5.4, and the midribs of about 5.0. The ratio of dry weight of blade to dry weight of midrib shows appreciable variations, the extreme values being 3.4 and 4.5. The high values correspond to leaves just below and just above the middle of the plant. The data for pH values and ratio of blade to midrib are very similar to those found for successive harvests in the 1943-44 season (2).

Data for the six harvests of the 1946-47 season, presented in Table XXVIII, show that although the maximum figure for total sugars of 30.01 per cent. approximated to the maximum figure of the previous season there was a wider range in sugar contents in 1946-47. Leaves of the first and last harvests were low in sugars, which gave low sugar : nitrogen ratios. Other harvests showed appreciably larger sugar values. Sucrose was higher in general than in 1945-46. The seasonal variation was in fact similar to that found in 1943-44 (2). In the leaves soluble ash, potash and nitrogen were generally higher than in 1945-46. Potash was at a more satisfactory level than in the previous season. The variation in chemical composition of the midribs was also appreciable Sugar contents, except for the first sample which was unusually well-supplied with sugars, followed the changes in the corresponding blade samples. As in the previous season the soluble ash, potash and phosphoric acid were higher than in the blades. Nitrogen did not show any consistent variation, the midribs being sometimes richer and sometimes poorer in this constituent than the corresponding blades. Whereas in 1945-46, the magnesia content of midribs was always greater than that of their blades, in 1946-47 the latter were the richer in the first three but the poorer in the last three samples.

General Discussion of Five Seasons' Results

The aim of the commercial grower is to produce tobacco satisfactory for the purposes of the manufacturer, hence the data presented above should be examined from this point of view. Haley and Reid (3) state that seed-bed plants which will produce a satisfactory crop in respect of both yield and disease resistance should have a ratio between their nitrogen and potassium contents (N/K) of approximately 0.6, presumably at the stage when they are set in the field. Examination of the data for the four seasons in which the necessary chemical data are available, either in the present paper or in the previously published report (1), shows that in only two of them did the plants have this optimum ratio between these two constituents ; in the other two the ratios were 0.4 and 0.5. If the value of 0.6 for this ratio is applicable to Nelson conditions, and of course it is not necessarily so, it seems that the plants used in these nutrient status experiments were in some cases in a sub-optimal condition. There is no field evidence however that they were so because satisfactory growth and freedom from leaf-spotting diseases was obtained in all five seasons.

Passing now to the cured leaf, the above-mentioned authors (3) state that flue-cured tobacco of the best quality contains, in the dry blade of the cured leaf, approximately 2 per cent. of nitrogen (N), at least 2 per cent. of potassium (K) and 18 to 25 per cent. of reducing sugars, and that any significant variation from these standards results in a poorer quality of leaf. They concluded that the best quality leaf was obtained when there were not less than three units of K_2O for each unit of N in the fertilizer employed in prodicing the plants. Moreover, the best quality was found when the fertilizer treatment was such that leaves from different parts of the plant contained approximately equal contents of potash. They also stated, " that potassium deficiency

actually exists in any tobacco plant that contains at maturity less potassium in the lower than in the middle and upper leaves and that such deficiency is associated with a definite lack of quality in all leaves of the plant". In a related paper (4) it is claimed that for good quality flue-cured tobacco the ratio N/K for blades should be 0.8-1.1. In most of their satisfactory samples this figure was about 0.9. Values on either side of the above range were associated with poorer or undesirable quality. Further, it was claimed that where the potassium and nitrogen were supplied to the plants in satisfactory proportions by use of suitable fertilizers the variations in climatic conditions during the growing and harvesting seasons exerted less effect on the quality of the leaf, but nevertheless "weather conditions prior to a priming may influence the composition of the leaves". Examination of the data for cured leaf of the 1944-45, 1945-46 and 1946-47 seasons and also for the 1943-44 season (2) shows that it was only occasionally that the N/K ratio for the blades fell in the desirable range. Moreover the nitrogen and/or potassium contents often were outside the stated figure of 2 per cent. for these constituents. The variations in nitrogen and potassium contents were such as would be expected from Haley and Reid's statement (3) that in dry seasons there is low intake of potassium and that rain after a dry period can result in poor quality leaf due to a sudden absorption of nitrogen. A striking example of this is shown in Table XXVII for the material harvested on 5th March. Heavy rain (1.25 in.) fell a few days before this harvest after a long dry period. It is noticeable that the response to nitrogen uptake was much more rapid than to potassium. Sugar content of this sample was relatively low also.

Effects of seasonal conditions noted in the above American papers (3, 4) can be traced also in the Nelson data. Thus in 1945 there appears to be a sufficiency of potash accompanied by very high sugar content of the leaf. This is characteristic of a wet season. In 1946 and 1947 the low potash content is indicative of dry conditions. The data of Gribbins *et al.* (4) indicate that two different types of variation in content of reducing sugars are to be found, one in which there is a steady decrease from the first harvest to the last, but all showing high values, and the other in which the middle leaves are much better supplied with sugars than the lower and upper leaves; thus in the latter case their middle leaves showed nearly double the sugar content of the other leaves. This type of variation occurred under Nelson conditions in the 1943-44 season (2); it is to be found also in the last experimental season of the present series of trials (see Table XXVIII). The other type of variation has been found in 1945 (Table X). In 1946, however, except for one sample, the sugar contents were all very high, the maximum figure for the season occurring at the fifth harvest. Variations in sugar content in passing from lower to upper leaves and type of season for some weeks before and during harvesting are set out below:

Season.	Conditions.	Sugar Content.
1943-44	Dry, then very wet*	low —> high —> low
1944-45	Wet	very high —> lower
1945-46	Dry, then moist*	high throughout
1946-47	Very dry*	low —> high —> low

* Crop was irrigated twice in 1944 and in 1946, and once in 1947, in January of each year.

From this classification there does not appear to be a definite correlation between the type of variation in sugar content and the weather conditions other than that dry conditions in both December and January tend to produce the low —> high —> low type. Use of irrigation water may have complicated the indications however. Further inquiry into this matter appears to be desirable in future seasons.

Yield is an important consideration in growing a crop commercially. It is of interest therefore to see how yield of harvested leaves varied in the different seasons. The most complete data available relate to crops grown on the medium sand ; they are set out below :

Season	Strain	Dry Matter lb. per acre
1942-43	Narrow-leaved	1222
1944-45	,, ,,	1231
1945-46	Broad-leaved	2369
1946-47	,, ,,	1875

The narrow leaved strain has given appreciably lower yields than the broad-leaved one ; moreover 1944-45 was a poor growing season. By courtesy of the Director of the Tobacco Research Station the weights of cured, graded saleable leaf from each harvest in 1946 were made available; from these the yield for the season was calculated to be 1973 lb. per acre. This is appreciably lower than the 2369 lb. given above and higher than the yield of 1710 lb. per acre from a neighbouring experiment in which the same fertilizer treatment was given as that for the nutrient intake experiment. A number of factors such as loss of dry matter during curing, varying percentages of moisture in cured leaf, and loss from low grade unsaleable leaf must be taken into account when considering the above differences. It is clear however that the broad-leaved strain is potentially one of high production characteristics, the yield even in the very dry 1946-47 being good.

One of the matters left for further investigation after the first two seasons' work was the confirmation or otherwise of the intake of nutrients and development of dry matter over the period of harvest. It can now be said that in each season a considerable proportion of the total intake has been absorbed by the plant after harvesting began. In general between one-third and one-half is taken up over this period. It is clear too from the detailed figures that absorption of nutrients generally continued when " nearly ripe " leaves passed to the " ripe " harvestable condition. At any one sampling date " ripe " leaves usually had a lower dry matter content than " nearly ripe " leaves ; but in passing to the " ripe " condition there was often a decrease in dry matter content. Changes in concentration of minerals and nitrogen also occurred. In general, lime content increased while potash and nitrogen contents decreased ; magnesia and phosphoric acid varied only slightly in most cases between the two maturity conditions.

During all the previous discussions of the chemical data no reference has been made to the insoluble ash figures which appear in the tables. This insoluble ash is a difference figure derived from the crude acid-insoluble residue from the total ash before and after treatment with dilute sodium hydroxide (5). It represents silica believed to be in the plant structure. From the tables already presented it is apparent that in some seasons, such as in 1945-46, appreciable amounts of structural silica may be present. It is not wise however to put too much emphasis on any suggested explanations for such variations as appear in the data.

Although two different strains of Harrison's Special variety have been used, one in three seasons and the other in two, it is of interest to set out the amounts of dry matter and nutrients in the unharvested leaves, laterals and stalks at the time when harvesting ceased. Data for these constituents are shown below, all being expressed as pounds per acre, and referring to crops grown on the medium sand of the Tobacco Research Station:

Season.	Dry Matter.			Nutrients.				
	Leaves etc. lb.	Stalks lb.	Total lb.	CaO lb.	MgO lb.	P_2O_5 lb.	K_2O lb.	N lb.
1941-42	318	1253	1571	17.1	6.8	9.8	47.2	27.8
1942-43	231	885	1116	13.5	5.1	6.4	35.0	14.2
1944-45	306	806	1112	16.0	5.4	5.4	40.5	18.5
1945-46	951	1602	2553	31.4	9.3	12.2	89.8	37.3
1946-47	334	1216	1550	22.5	7.6	7.8	48.0	20.9
Averages	428	1152	1580	20.1	6.8	8.3	52.1	23.7

If the somewhat unusal figures of the 1945-46 trial, due to the phenomenal growth of laterals in the second half of March in that season, are excluded, there are no very great variations for a given constituent from one season to another. In one season lime and potash may be relatively high and in another potash and nitrogen. The 1945-46 figure is of value however in demonstrating what may happen in a season with a good autumn rainfall after a dry summer. Taking the average figures for the five seasons the nutrients available represent per acre, 36 lb. of calcium carbonate, 36 lb. of dolomite, 40 lb. of superphosphate, 108 lb. of sulphate of potash (48 per cent. K_2O) and 116 lb. of sulphate of ammonia. The two latter fertilizer materials are expensive; consequently the addition of the equivalent of approximately 1 cwt. of each per acre in the crop residues is particularly valuable. Of the dry matter the stalks form the bulk, amounting on the average to 1152 lb. per acre ; if disced in or ploughed down in the fresh state stalks will rapidly decompose in the soil and help to maintain the organic matter content of the soil. The 428 lb. of leaves and laterals will also readily break down in the soil. On the heavier soil used in the trials the return of nutrients will be somewhat greater, especially in respect of potash and nitrogen, than on the lighter soil of the Research Station. Return of organic matter may be expected to be greater also. Altogether therefore it is to the advantage of the grower to get these residues into his soil as soon as possible after harvesting is completed. In any case this should be done before the plants are damaged by frost and other adverse conditions.

ACKNOWLEDGMENTS

It is a pleasure to record the co-operation of Mr. R. Thomson, Director of the Tobacco Research Station, in these trials in attending to the cultural operations, harvesting and curing of leaf and in providing rainfall and yield data. Mr. F. A. Hamilton kindly gave the use of land and attended to the cultural requirements of the crops on the heavier soil. Much assistance on the laboratory side has been given by Messrs. A. Schwass and K. Christian.

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A TEST OF THE COMBING PERFORMANCE OF WOOL, SHIPPED AFTER SCOURING.

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(*Received for publication, 10th October, 1947*)

Summary

This processing trial was designed to test the contention of some English top makers that colonial wools, when scoured before shipment, are unsuitable for combing because baling and transport result in entanglement and felting of the wool and so cause an unsatisfactory tear in combing.

Three quarters of a lot of 3,224 lb. greasy weight of sorted 58's warp quality wool was scoured and divided into three parts. One part was baled, double-dumped and shipped the return journey from New Zealand to England, one part was baled, double-dumped and held at the mill, and the third part was loosely packed and held at the mill. The unscoured quarter was baled, double-dumped and shipped the double journey along with the double-dumped scoured wool and finally scoured on its return. Thus there were four lots for the subsequent combing test.

Each lot was processed into tops by identical procedures except that the double-dumped scoured wool was given an extra passage through the willey. Measurements were made on each lot with respect to tear ratio, fibre length of top and card sliver and the nep count of the card sliver. Neither these measurements nor the observed performance from carding to combing revealed any differences of industrial importance between the lots of wool treated in the four different ways prior to processing.

INTRODUCTION

GREASY wool production in New Zealand amounts to between 120,000 and 140,000 tons annually, and of this quantity, more than 90 per cent. is shipped overseas for processing. The average yield of clean scoured fibre in the clip is probably between 65 and 68 per cent. (cf. Henderson and McMahon, 1947), so that shipment in the grease involves the carriage of over 38,000 tons of unwanted impurities long distances by sea and other transport. One of the objections raised to carrying out the initial stages of processing in the Dominion is the suggestion that scoured wool suffers felting during transit, resulting in increased fibre breakage during carding and combing, and decreasing the proportion of "top" obtained.

Modern work suggests that the principal cause of felting is not the interlocking of cuticular scales of adjacent fibres brought about by pressure (de Witt, 1888), but rather entanglement which occurs when the fibres "creep in much the same way as a worm crawls" (Arnold, 1929). "Creeping" is made possible by directional effects due to the scales and by the unique elastic properties of the wool fibre. It is facilitated by the softening effect of moisture, by high acidity or

moderately high alkalinity, and can only take place when the fibrous mass is subjected to movement with alternate application and release of stress to individual fibres, such as occurs during washing, milling and felting. Under these circumstances, it is clearly most unlikely that fibre creep can occur in a dry mass of scoured and rinsed wool, tightly pressed in the wool bale and then double-dumped and secured with wire or iron bands. If wool scoured before shipment does in fact give inferior combing results, it is much more likely to be due to fibre damage caused by treatment during scouring, or to a certain degree of felting having occurred in the scouring bath, where conditions are such that this could readily take place. At the same time, the possibility must not be excluded that disappointing combing results in mills accustomed to scouring their own material have been due to insufficient appreciation of the behaviour of fibres subjected to constraint for periods of several months. Although wool is one of the most elastic of our textile materials, deformed fibres do not always return to their original relaxed dimensions immediately the cause of deformation is removed. Rinsed wool subjected to the scouring process is brought to the card in a completely relaxed and lofty state, whereas wool which has been pressed after scouring requires more opening, preferably in a damp atmosphere, to release the temporary sets which the fibres have sustained.

THE RAW GREASY WOOL

A sorted commercial lot of New Zealand wool in the grease, 58's combing warp quality, total weight 3,224 lb., yielding 67.3 per cent., and supplied by the Bruce Woollen Manufacturing Co., Ltd., Milton, New Zealand, was chosen for the test.

TREATMENT PRIOR TO THE PROCESSING TRIAL

General Scheme.

Sorted Wool, 3,224 lb., greasy

Scoured ¾ of total and packed into bales			¼ of total packed into two bales in the grease
2 bales double-dumped and shipped N.Z. to England and return. (Lot 1)	2 bales double-dumped and held at mill. (Lot 2)	Bales loosely packed and held at mill. (Lot 3)	2 bales double-dumped, shipped N.Z. to England and return and finally scoured. (Lot 4)

For subsequent processing each lot was split into two parts called Batch A and Batch B, each bale forming the unit where possible.

Scouring.

The scouring of the wool was carried out in a four bowl set, three feet wide, harrow type, to meet the requirements for high quality worsted processing.

The greasy wool, after passing through a Taylor Wordsworth double cylinder willey (the front and back cylinders ran at 480 and 580 R.P.M. respectively), was fed to the scouring set by means of an automatic feeder at about 420 lb. per hour. The first two bowls were each of 1,900 gallons and contained respectively 0.15 per cent. and 0.04 per cent. of soap and 0.07 per cent. and 0.01 per cent. soda ash. The third bowl contained water only and fresh warm water was supplied

continuously to the rinse bowl. The temperatures were 126°F. for the first and second bowls, 120°F. for the third bowl, and 100°F. for the rinse bowl. Before commencing to scour the wool the liquors were run in on merino pieces for two hours. During scouring, measurements of pH and temperature of the liquors were made at hourly intervals, and when necessary, at shorter intervals.

The scoured wool was dried in a three-tier Taylor-Wordsworth dryer operating at 150°-165°F.

In scouring the two bales of greasy wool returned from England, care was taken to give it the same treatment as was given the portion corresponding to Lots 1 and 3.

The mean results of analyses of the scoured wool are given in Table I.

TABLE I. ANALYSES OF SCOURED WOOL

Lot No.	Grease Content. Mean. (Per cent.)	Grease Content. Range.	Absolute Alcohol Extract (after pet. ether). (Per cent.)	Sorbed Alkali as NaOH. (Per cent.)
1-3	0.69	0.27 per cent. to 1.2 per cent. on 17 tests	0.81 (mean of 3 tests)	0.34
4	0.97	0.61 per cent. to 1.44 per cent. on 7 tests	1.00 (mean of 4 tests)	0.37

Baling.

Before baling, the scoured wool corresponding to Lots 1 to 3 was allowed to lie for four weeks in bins by which time it reached an average regain of 11.9 per cent.

Standard jute packs were used for baling each lot. The bales were then treated as shown in Table II.

TABLE II. DETAILS OF BALING

Lot No.	Bales.	Weight of each bale. (lb. net)	Treatment of bales.
1	2	274, 274	Double-dumped and shipped.
2	2	270, 274	Double-dumped and held at the mill.
3	6	91 (mean)	Loosely packed and held at the mill.
4	2	340, 341	Double-dumped and shipped.

Lots 1 and 4, after double-dumping, were shipped to England per the "Antar" and returned to New Zealand per the "Rimutaka". All the lots remained in bales for seventeen months with the exception of Lot 4 (fourteen months) before further processing, Lots 1, 2 and 4 being in double-dumped form.

PROCESSING TRIAL

For subsequent processing each lot was divided approximately into halves, taking a bale for each unit in the case of Lots 1, 2 and 4, thus giving eight batches designated as 1A, 1B, 2A, 2B, 3A, 3B, 4A, 4B. Processing was carried out in the following batch order: 3A, 2A, 1A, 4A, 4B, 1B, 2B, 3B.

All the machinery used was made by Taylor Wordsworth and Co., Ltd., and suitable for processing fine crossbred wools.

Opening.

Each batch was first put through a double cylinder willey or opener of the following characteristics :—The cylinders were 28 in. in diameter, studded with spikes 2½ in. long, and of effective width 28 in. The nip of the fluted feed roller could not close to less than ¼ in. and was located 2½ in. from the tips of the spikes of the first cylinder. The speeds of the first and second cylinders were respectively 383 R.P.M. and 453 R.P.M. and the surface speed of the feed rollers was 22.7 ft. per minute.

After observing that the rates of carding production of Batches 1A and 2A were greater (most probably due to compact pieces of wool falling into the weigh pan of the automatic feed and reducing its precision of weighing) than for the other batches, the decision was made to increase the degree of opening of Batches 1B and 2B by a second passage through the willey.

Carding.

A medium worsted card, 60 in. wide, of conventional design and with automatic feed was used, the speed of the swifts being between 109 and 112 R.P.M.

In preparation for the trial, the card clothing was ground and run for six days followed by fettling and a further run for two days on 60's wool. The card was again fettled and run-in between Batches 4A and 4B.

Before feeding to the card the opened wool was weighed, regain determined, and oiled on the floor with a stirrup pump using an emulsion of batching oil (JB/QSX by Benj. R. Vickers and Sons Ltd.) calculated to give ¾ per cent. added oil and 24 per cent. mean regain on the wool.

The automatic feed to the card was set to give an average output of 60 to 64 lb. per hour and remained unchanged throughout the trial.

The carding production was measured by weighing the contents of each can as it was taken off at 15 minute intervals. The temperature and relative humidity of the atmosphere at the card was measured by a wet and dry bulb whirling hygrometer at 90 minute intervals.

Samples of card sliver, each about 9 feet long, were taken during carding from can Nos. 3, 8 and 14 in order of production for measurements of fibre length and nep count.

Backwashing to Punchballing.

The card sliver was backwashed in a two-bowl machine, with a 9 cylinder dryer, and a double-headed machine delivering into cans. A 0.13 per cent. soap liquor was used in the first bowl and rinsing water in the second, the bowls being made up fresh for each batch. The average liquor temperatures were 110° - 115°F. and the drying temperature about 152°F. yielding a sliver at approximately 22 per cent. regain at the backwash gill where 3 per cent. of batching oil (Vickers JB/QSX) was added.

The slivers from the backwash gill were passed through one strong box and on to the punch box where 13 lb. balls were made, except that in Batch 4B the balls were 12¼ lb. The drafting data are given in Table III.

Combing.

In combing by the Noble comb, care was taken to ensure that the settings of the feed knives and the draw-off rollers remained the same for processing each lot. The feed knives were kept set in one position. The dabbing brushes were in good condition.

Measurement of the tear ratio was carried out by weighing the sliver and noil corresponding to groups of three cans and single cans in succession, but rejecting the last three cans with the corresponding noil because of possible irregularity due to the punch balls beginning to run out.

From the second finishing gill, a top sliver of 5 oz. per 10 yd. was delivered in balls of mean weight 8 lb. 2 oz. The drafting data are given in Table III.

TABLE III. DRAFTING DATA

Operation.	Weight of Sliver fed to Machine. (oz. 10 yd.)	Number of Ends up.	Draft.
Backwash gill	10.0	10	7.8
Strong box	12.8	5	6.8
Noble comb	9.4	72	—
1st Finishing gill	2.6 approx.	16	5.75
2nd Finishing gill	7.2 ,,	4	5.8 approx.

Samples of top for fibre length measurement were taken from four balls distributed over each batch.

RESULTS AND DISCUSSION

State of the Scoured Wool.

Batches 1A and 1B smelled a little musty in the centres of each bale after breaking open, but the appearance of the wool under ultra-violet light or under the microscope or after staining with methylene blue did not differ from the other batches.

Opening.

The higher carding production rate for Batches 1A and 2A shown in Table VI indicated a lower degree of loftiness for these compared with the other willeyed lots and this was also apparent to the eye. After passing Batches 1B and 2B twice through the willey this difference was no longer apparent and the carding rate was restored to normal.

The weights of sweepings from under the willey are shown in Table V. In view of the variable nature of these impurities it is considered that the differences between the figures have no importance.

Carding.

All lots ran satisfactorily.

The atmospheric conditions at the card are shown in Table IV.

TABLE IV. ATMOSPHERIC CONDITIONS AT CARD

Batch No.	Temperature in °F. at			Per Cent. Relative Humidity at		
	15 min.	105 min.	240 min.	15 min.	105 min.	240 min.
1A	77	77	77	51	49	49
1B	72	76	—	49	51	—
2A	83	83	82	48	53	53
2B	82	82	77	48	50	52
3A	72	86	86	56	46	47
3B	79	79	77	57	45	43
4A	75	78	78	60	53	53
4B	74	71	78	43	41	38

The temperatures during carding would all be regarded as satisfactory but the humidity of the atmosphere was rather low while carding Batch 4B and part of Batch 3B. No effects of static electricity were noticed however.

Card waste collected as sweepings from under the card is recorded in Table V. Again the variable nature of the sweepings is the reason for regarding the differences between the figures as of no importance.

TABLE V. WILLEY AND CARD WASTE

Batch No.	Weight of Batch after opening.	Sweepings.	
		Willey.	Card.
	lb.	lb. oz.	lb. oz.
1A	280	0 10	0 8
1B	276	1 7	0 10
2A	281	1 4	0 3
2B	279	1 5	0 14
3A	287	— —	1 9
3B	254	1 3	0 7
4A	220	0 11	0 4
4B	220	0 11	1 2

The nep contents of the samples of card slivers were counted on foot lengths (about 10 g.) of two sliver samples from each batch by the method of Townend and Spiegel (1944) and the results are recorded in Table VI. The relatively high number of neps for Batches 4A and 1A can probably be explained as being due to the fact that these batches were the last two carded before fettling. The differences found between the other batches are not significant.

The results of fibre length measurements on the samples of card sliver by the cut-squaring-method described by Daniels (1942) are recorded in Table VI.

TABLE VI. FIBRE LENGTH AND NEP COUNT OF CARD SLIVER

Batch No.	Fibre Length.					Nep Count as neps per g.		Carding Production (lb. per hour)
	No. of fibres measured.	Mean Length. (cm.)	* S.D. (cm)	* S.E. (cm.)	* C. of V. (Per cent.)	Separate Results.	Mean.	
1A	1,393	7.22	4.98	.13	68.9	25, 30	28	71
1B	1,332	6.93	4.86	.13	70.1	18, 16	17	64
2A	1,504	7.03	4.96	.13	70.6	14, 20	17	74
2B	1,838	7.02	5.03	.12	71.6	22, 21	22	63
3A	1,313	7.06	5.00	.14	70.7	15, 19	17	61
3B	1,756	7.69	5.09	.12	66.2	14, 21	18	64
4A	1,416	7.14	5.04	.13	70.6	34, 30	32	60
4B	1,407	6.98	4.90	.13	70.2	17, 23	20	61

* S.D. = Standard Deviation. S.E. = Standard Error. C. of V. = Coefficient of Variation.

The results of fibre length measurements on the card slivers are shown graphed as cumulative diagrams (corresponding to Baer diagrams) in Fig. 1 which shows the "B" series only. Curves for series "A" are not shown but they follow closely those for 1B, 2B and 4B.

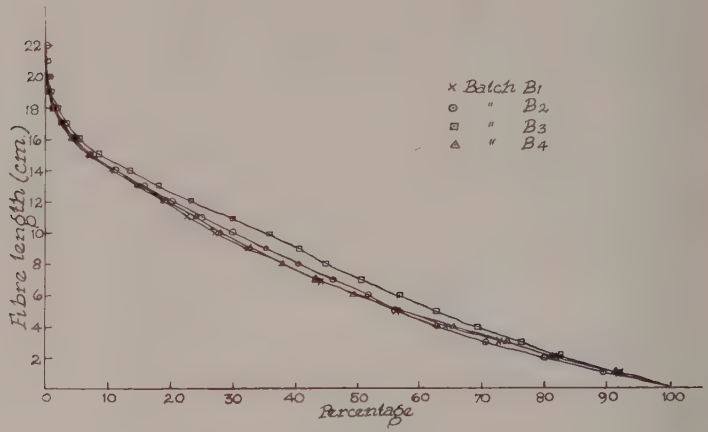

FIG. 1

The mean fibre length of the card sliver of Batch 3B is significantly longer than for the other batches and could be of practical importance, but it is not confirmed by its duplicate Batch 3A nor is it supported by Batches 4A and 4B. Although the difference in the mean fibre length between Batches 1A and 1B is statistically significant it is considered too small to be of practical importance. The other differences in mean fibre length are not significant.

Combing.

The cut-squaring-method of Daniels (1942) was also used for determining the fibre length of the tops, the samples being taken from four balls distributed over each batch. These results, together with the tear ratios, are shown in Table VII. Results for Batches 1A, 2A, 3A and 4A are not given because, owing to a misunderstanding, a gilling was omitted before combing. The fibre length measurements are shown plotted as cumulative diagrams in Fig. 2. Again the fibre length measurements have failed to reveal, with the exception of Batch 3B, any

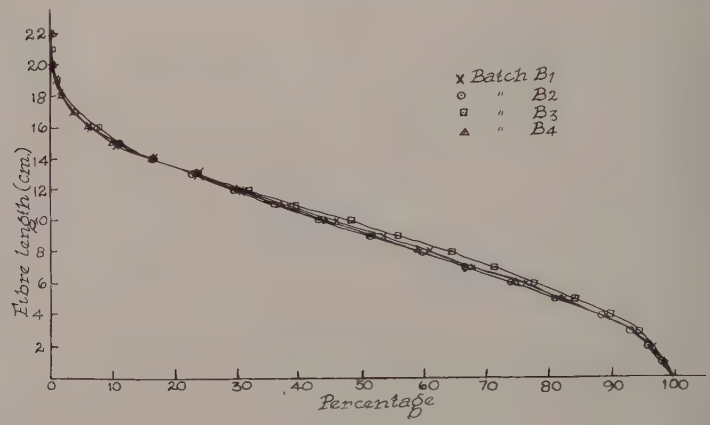

FIG. 2

differences of practical significance between the lots. The slightly greater mean fibre length of Batch 3B is supported by the results of measurements on the card sliver but is not supported by corresponding measurements on Batch 4B. Possibly the fact that Batch 3B was the last one processed contributed to its slightly superior performance.

Included in Table VII are the results of fibre-fineness measurements on the tops under the projection microscope. The fineness figures do not appear to warrant comment other than that the quality number of the tops approximates 56's on the Bradford scale.

No importance can be attached to the differences shown between the figures for the top to noil ratios, which, from an analysis of the weights measured during combing, are not statistically significant.

TABLE VII. TEAR, FIBRE LENGTH AND FIBRE DIAMETER OF TOPS

Batch No.	Top to Noil Ratio.	Fibre Length.					Fibre Diameter.			
		No. of Fibres.	Mean Length (cm.)	S.D. (cm.)	C. of V. (Per cent.)	S.E. (cm.)	Mean Diam. (μ)	S.D. (μ)	C. of V. (Per cent.)	S.E. (μ)
1B	6.05 : 1	1602	9.42	4.31	45.8	0.11	28.9	6.4	22.2	0.23
2B	6.43 : 1	1677	9.29	4.39	47.3	0.11	28.7	6.5	22.6	0.29
3B	6.09 : 1	1689	9.66	4.29	44.4	0.10	28.3	6.1	21.6	0.28
4B	6.21 : 1	1987	9.33	4.39	47.1	0.10	27.9	6.5	23.2	0.24

CONCLUSIONS

It is considered that no differences of industrial importance were found in the carding and combing properties of the wool irrespective of whether it was scoured and double-dumped before shipment, double-dumped in the grease before shipment, scoured and stored after double-dumping, or scoured and stored loosely packed.

ACKNOWLEDGMENTS

Thanks must first be accorded to the Department of Scientific and Industrial Research, by whose grant the investigation was made possible, and to the Executive of the New Zealand Woollen Mills Research Association (Inc.) for its permission to carry out and report this work. The generous co-operation of the Bruce Woollen Manufacturing Co., Ltd., has been greatly appreciated. Special thanks are due to the members of the staff of the New Zealand Woollen Mills Research Association (Inc.) without whose assistance this test could not have been carried out.

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POLLEN IN HONEY AND BEE LOADS

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(*Received for publication, 4th July, 1947*)

Summary

Samples of honey and bee loads obtained from test hives situated within "bee range" of native bush, scrub and pasture, at Pongakawa, New Zealand, were examined for their pollen content. It was found that during the season November, 1945, to March, 1946, the pollen of only a few of the species in this area, which are known to be visited by honey bees, was recovered in the honey and bee loads. Most of the pollen in the honey came from scrub (manuka), pasture and waste places (clover, lotus, catsear, hawkbit, and thistle). Native bush was represented by a small percentage of rewarewa. The principal pollen types in the bee loads were from pastures and roadsides (lupin, clover thistle, lotus, catsear, hawkbit, and plantain).

INTRODUCTION

IT is desirable to know to what extent different honey types are characterized by their pollen content. The source of the parent nectars cannot be deduced from the pollen content of the honey without reference to other characters and to methods of extraction, but cases do arise in which it is desirable to identify the pollen in honey. Under suitable conditions much can still be learned concerning the activity of honey bees at different seasons in particular localities, from the study of the pollen content of honey samples and bee loads. The present paper deals with a series of honey samples and bee loads which were examined in connection with the botanical aspects of a recent outbreak of honey poisoning investigated by the Department of Agriculture. A general description of the area, and of the manner in which the samples were obtained, is given elsewhere (Harris and Filmer, 1947, and Paterson, 1947).

The sources of honeys in New Zealand were discussed by Cockayne (1916), and more recently by Winter (1946), and have also been the subject of numerous articles concerning particular localities. However, little published work exists concerning the pollen in New Zealand honeys. Waters (1915-6) gave detailed descriptions of a few pollen types, but pollens of indigenous plants were not dealt with. Since Waters' descriptions were published, his methods of preparation have been superseded by methods evolved in the northern hemisphere, where considerable attention has been given to pollen morphology, and to the identification of pollens in peat, on atmospheric slides and in honey. The only available key for the identification of the pollens of indigenous plants (Cranwell, 1942), is based on these more recent methods of preparation, but lacks illustrations and is complicated by the inclusion of many pollen types unlikely to concern the investigator of honey pollens. There is therefore, little information available concerning pollen types in New Zealand honeys, which is based on the newer methods of preparation, and covers both exotic and indigenous species.

POLLEN AND NECTAR FLORA

The apiary was situated in the Pongakawa Valley where native bush, scrub and pasture were within " bee range " of the hives. A botanical survey was carried out to determine the species available to bees in this area, and nearly 200 were noted (see Appendix). A relatively large proportion of these (about two-fifths) was cultivated, in many cases represented by only a few individual plants. The scrub contained fewer species, which, however, were more abundant. In the small area of bush examined some 40 species were observed, mostly trees and shrubs, of which only a few were entomophilous, and none were abundant. One third of the species listed were weeds and herbs occurring in pastures, on roadsides, or in waste places, mingling at times with the scrub. Some few of these were sufficiently abundant to be of importance to bees, as the pollen results show. Sixty-one of the species recorded are known to be worked by bees for pollen, and 150 species are known to be nectar plants, 66 of which have been reported to be visited by bees.

MATERIALS

(*a*) *Honey :*

The honey and pollen samples were collected by Mr. C. R. Paterson, Apiary Instructor, Department of Agriculture, Hamilton, and forwarded for investigation.

To secure samples of incoming honey collected over definite periods the following procedure was adopted. " Prior to the commencement of the tests the bees were allowed to use up all stored honey. Sugar syrup was then fed to sustain them until the first spring nectar was available. To ensure that a sample of honey covering a definite period would be secured, hives A and B were both kept overcrowded and one or two empty drawn-out combs were placed in an appropriate position in the hives and the date noted. After samples had been cut out from these combs covering a period of approximately 14 days they were replaced by fresh empty combs. In this way it was considered that a complete coverage of all incoming nectar and pollen would be obtained." (Paterson, 1947).

A weighed amount of honey, 25 or 50 g., was dissolved in warm water and the pollen content concentrated by centrifuging. Pollen was either stained with basic fuchsin or treated by Erdtman's " acetolysis " method (Erdtman, 1943).

(*b*) *Bee Loads :*

" Samples were secured by placing a pollen trap at the entrance of hive B. The bees in this hive were of a black strain, while those in hive A were Italian. The bees very soon became accustomed to forcing their way through the trap, the pollen being knocked off their legs in the process, and collected in a tray at the bottom." (Paterson, 1947).

The pellets were mostly lenticular in shape, and various colours. The pellet size and weight were less variable than the colour, for most of the pellets were about 3 mm. long, and weighed about 1 mg. (air dry). From each sample of bee loads a random lot of over 200 pellets was taken for detailed examination. These pellets were grouped according to their colour, and each colour group was examined for consistency of pollen type, and sorted accordingly. The percentage of each pellet type in the bee load sample was then estimated.

IDENTIFICATION OF POLLENS

Identifications were made by reference to keys*, illustrations†, and a set of pollen slides prepared from the species noted in the botanical survey of the district.

It is not always practicable to separate pollens of closely related plants, so for statistical purposes we have designated these pollen types by the vernacular name of one of the common species each represents. However, the application of this rule varies according to circumstances, as species not known to occur in the locality were not taken into consideration.

The following are the principal pollen types encountered in this study.

IMPORTANT POLLEN TYPES IN HONEY AND BEE LOADS

POLLEN TYPE	SPECIES REPRESENTED
Catsear	*Hypochaeris radicata* L. (catsear), *Leontodon hispidus* L. (hawkbit).
Clover	*Trifolium* species—*T. pratense* L., *T. repens* L.
Lotus	*Lotus uliginosus* Schkuhr. (*L. major* Sm.).
Lupin	*Lupinus arboreus* Sims.
Manuka	*Leptospermum scoparium* Forst., *L. ericoides* A. Rich. (and possibly other *Myrtaceae*).
Thistle	mostly *Cirsium lanceolatum* (L.) Hill.

POLLEN TYPE	SPECIES REPRESENTED	HONEY	BEE LOADS
Buddleia	*Buddleia* spp.	—	+
Caryophyllaceae	All species	+	—
Compositae	All species	+	—
Conifer	Pines, etc.	+	+
Ericaceae	All species	+	+
Grass	All species	+	+
Malva	*Malva* spp.	+	+
Pigeonwood	*Hedycarya arborea* Forst.	—	+
Plantain	*Plantago lanceolata* L.	—	+
Tutu	*Coriaria arborea* Lindsay.	+	—

POLLEN RESULTS

(*a*) *Pollen content of honey:*

There are acknowledged difficulties in correlating quantitatively, or even qualitatively, the pollen in honey with the sources of nectar (Melville, 1945). It is remarkable, however, that the pollen results are fairly consistent over a period, whereas, if there were no relationship between the proportion of pollen and of the parent nectars, a more fortuitous occurrence of the pollen maxima might be expected.

Details of the pollen content of the samples are given in Table I.

Though manuka was the predominant pollen throughout the period studied, and though there was also a small but constant percentage of rewarewa pollen in November and December samples, introduced species were represented by the greatest diversity of pollen types. In December there was a high proportion of clover pollen in sample (ii) taken from the hive on the 15th, which may have been caused by favourable weather conditions. The bee load sample taken on the same day was composed entirely of white clover pollen. Throughout February there was a small but constant percentage of thistle pollen, and in sample (ii) taken from the hive on 15th March, when *Cirsium lanceolatum* was in full flower, there was 46 per cent. thistle pollen.

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* Cranwell (1942), Wodehouse (1935).

† Wodehouse (1935, 1945), Armbruster and Oenike (1929).

During the botanical survey of the area, 66 species were observed which are known to be visited by honey bees for their nectar, and 56 of these could be represented by the pollen types recognized in the honey samples.

(*b*) *Pollen content of bee loads :*

Pollen contains foods essential for the bees, and where a choice is available selection is made according to their " tastes ", the selection being based on the relative abundance of certain materials in the respective pollens. The area in which the apiary was situated provided a variety of plant communities and pollen types within " bee range " of the

TABLE I. PERCENTAGE POLLEN CONTENT OF HONEY SAMPLES

Date.	Sample.	Manuka.	Rewa-rewa.	Clover.	Lotus.	Catsear.	Thistle.	Others.
1945								
*Feb.	Unfit for use	61	1	14	15	2	1	6
Nov.								
17	i	93	1	3	—	—	—	3
	ii	82	4	5	—	—	—	9
29	i	61	11	22	1	—	—	5
	ii	71	3	12	1	4	—	9
Dec.								
15	i	76	2	15	—	2	—	5
	ii	0	1	67	11	—	1	—
29	i	73	1	9	10	—	1	6
	ii	94	—	1	2	—	1	2
1946								
Jan.								
7	i	87	—	8	5	—	—	—
	ii	82	—	3	11	—	1	3
14	i	58	—	32	6	—	—	4
	ii	97	—	3	—	—	—	—
21	i	87	—	6	—	6	—	1
	ii	91	—	4	1	—	1	3
Feb.								
3	i	90	—	4	—	—	3	3
	ii	90	—	6	3	—	1	—
21	i	55	—	31	2	—	7	5
	ii	71	—	10	13	—	6	—
Mar.								
15	i	85	—	3	3	1	7	1
	ii	17	2	15	1	18	46	1

* Sample from the same locality, included for comparison.

apiary, but the bee loads examined showed that the bees had worked only a few of the pollen types available and these principal types were most common in pastures and waste lands. Thus the main sources of pollen were, lupin in November, clover in December, lupin and thistle in January, and thistle in February. Small amounts of lotus, catsear, hawkbit, and plantain pollen were also found (see Table II).

The differences in colour observed in pellets composed of the same pollen type may be influenced by the presence of varying amounts of wax, and/or, by the presence of other pollen types. Traces of other pollen types might be attributable to contamination, either of the flower by wind- or insect-borne pollens, or from the honey with which the pollen load is moistened. Mixed loads, containing high proportions of two or more pollen types were found, probably when certain types were in limited supply. Thus thistle was found in mixed loads early in February, but later in pure loads and in much greater abundance.

COMPARISON OF IMPORTANT POLLEN TYPES IN HONEY AND BEE LOADS

	HONEY	BEE LOADS
November	manuka	lupin
December	manuka, clover	white clover
January	manuka	lupin, thistle
February	manuka	thistle
March	manuka, thistle	thistle

TABLE II. POLLEN CONTENT OF BEE LOADS

Date. 1945	Pellet Colour.	Pollen Type.	Percentage of Pellets per Sample.
Nov. 17	Deep orange	lupin	1
	Orange	lupin	68
	Lemon	lupin	17
	Pale lemon	lotus	4
	Green-black (mixed)	thistle, lupin	10
29	Orange	lupin	93
	Lemon	lupin	5
	Pale lemon	*Buddleia*	1
	Black	thistle	1
Dec. 15	Orange	*Trifolium repens*	87
	Lemon	*Trifolium repens*	13
	Lemon to orange	*Trifolium repens*	
1946			
Jan. 7	Deep orange	lupin	15
	Orange	lupin	42
	Lemon (mixed)	lotus and thistle	31
	Brown (mixed)	lotus and lupin	8
	Grey	lotus	4
14	Deep orange	lupin	8
	Orange	catsear	1
	Lemon	thistle	79
	Brown (mixed)	lupin and lotus	8
	Grey	thistle	8
21	Deep orange	lupin	2
	Orange	catsear	4
	Lemon	thistle	86
	Brown	lupin	3
	Grey	thistle	5
Feb. 3	Deep orange	lupin	1
	Orange	catsear	12
	Light orange	catsear	
	Yellow (mixed)	thistle and monocotyledon	1
	Fawn lemon	thistle	86
	Fawn white	thistle	
	Grey-black	thistle	
21	Deep orange	lupin	13
	Orange	catsear	25
	Lemon	thistle	50
	Bright lemon	thistle	1
	Grey	thistle	8
	Blackish	thistle	3
Mar. 15	Deep orange	catsear	14
	Orange	catsear	
	Light Brown	thistle	75
	Yellow brown	thistle	
	Brown (mixed)	lupin and Myrtaceae	4
	Mixed brown	lupin and Myrtaceae	1
	Blackish	thistle	1
	Grey	thistle	4
	White	thistle	1

Some of the honey produced in this locality prior to the present investigation was said to be difficult to extract—a characteristic of manuka honey. Though there was generally a high percentage of manuka pollen in the samples examined, other species may have been more important nectar sources than the pollen statistics indicate. Rewarewa, for example, which is represented by a much smaller percentage of pollens, has a more specialized type of flower and a larger pollen. Possibly rewarewa honey might contain less pollen than manuka honey.

It is interesting to note that the flowers of *Lupinus* were described by Knuth (1908, p. 271), as " nectarless bee flowers ", for in the bee loads examined here lupin pollen was important, but very little was found in the honey.

Small amounts of pollen from plantain, pigeonwood, and buddleia were found in the pellets, but not in the honey. This indicates that the bees have worked these plants only for pollen (plantain, pigeonwood), or that pollens were present in only small numbers in the honey and were missed in sampling (*Buddleia*, Howes, 1945).

CONCLUSIONS

The above results do not afford comparisons between different localities or honey types, but the data are presented for possible future use in this connection. Should future work along these lines be indicated, a key, with illustrations and brief descriptions would facilitate recognition of the main pollen types likely to be encountered.

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APPENDIX I

THE PLANT LIST

The plant list was compiled during the botanical surveys of the area by W. F. Harris and A. J. Healy (November, 1945) and H. E. Connor (February, 1946). Literature was consulted for references to the utilization of flowers as nectar or pollen sources, with the primary object of devising a guide for the identification of pollens in honey and bee loads. In this appendix the authorities referred to are designated by numerals as indicated at the end of the list.

PLANTS OBSERVED DURING BOTANICAL SURVEYS OF THE PONGAKAWA DISTRICT

Common Name.	Botanical Name.	Nectar Flowers.	Pollen Flowers.	Worked by Bees.
Alyssum	*Alyssum* sp.	7	7	7
Anchusa	*Anchusa* sp.	7	9	7,9
Antirrhinum	*Antirrhinum majus*	6,7	7	7
Apple	*Pyrus malus*	7	7	7
Arctotis	*Arctotis* sp.			
Azalea	*Azalea* sp.	6,7		
Barberry	*Berberis vulgaris*	7,8	7,9	7,8,9
Bean, broad	*Vicia faba*	7	9	7,9
Bean, kidney	*Phaseolus vulgaris*	3		
Bedstraw, native	*Galium umbrosum*	4		
Beet	*Beta vulgaris*	6		
Bluebells, native	*Wahlenbergia gracilis*	3		
Blueberry	*Dianella intermedia*			
Bluegum	*Eucalyptus globulus*	3		3
Broadleaf	*Griselina littoralis*		4	
Broom	*Cytisus monspessulanus*			
Tree lucerne	*C. proliferus*	3		
Broomrape	*Orobanche minor*	6		
Buddleia	*Buddleia* sp.	7	9	7,9
Buttercup, native	*Ranunculus hirtus*			
Buttercup	*R. repens*	2,8	9	8,9
Bushlawyer	*Rubus cissoides*	3		
Californian poppy	*Eschscholtzia californica*	7	7,9	7,9
Canterbury bells	*Campanula* sp.	7	7,9	7,9
Cardamine, native	*Cardamine heterophylla*	6		
Carnation	*Dianthus* sp.	6	9	9
Catchfly	*Silene gallica*	1		
Catmint	*Nepeta* sp.	7		
Catsear	*Hypochaeris radicata*	3,8	3	8
Cherry, flowering	*Prunus cerasus*	7	7	7
Chickweed	*Stellaria media*	7	7,9	7,9
Chrysanthemum	*Chrysanthemum* sp.	6		
Cleavers	*Galium aparine*	4		
Clover, red	*Trifolium pratense*	7,8	9	7,8,9
Clover, subterranean	*T. subterraneum*	6		
Clover, suckling	*T. dubium*	7		7
Clover, white	*T. repens*	7	9	7,9
Columbine	*Aquilegia* sp.	2	7,9	7 9
Coneflower	*Rudbeckia* sp.	7		7
Coprosma, broad-leaved	*Coprosma australis* (*C. grandifolia*)		4	
Cornflower	*Centaurea cyanus*	2	9	9
Cudweed, purple	*Gnaphalium purpureum*	4,6		
Currant, flowering	*Ribes glutinosa*	6		
Daisy, native	*Lagenophora pumila*	6		
Dandelion	*Taraxacum officinale*	7,8	7,9	7,8,9
Delphinium	*Delphinium* sp.	2	9	9
Dock, broad-leaved	*Rumex obtusifolius*		+	
Earina	*Earina mucronata*	4		
Epilobium	*Epilobium* sp.	7	7	7
Evening primrose	*Oenothera* sp.		6	
Evonymus (spindle tree)	*Evonymus japonica*	1		
False-acacia	*Robinia pseudacacia*	3,7		3,7

Common Name.	Botanical Name.	Nectar Flowers.	Pollen Flowers.	Worked by Bees.
Fathen	*Chenopodium album*		+	
Fireweed, Australian	*Erechtites atkinsoniae*	6		
Fivefinger	*Nothopanax arboreum*	4		
Flax, Australian	*Linum marginale*	1		
Fleabane	*Erigeron crispus*	6,7		7
Foxglove	*Digitalis purpurea*	6		
Fuchsia, native	*Fuchsia excorticata*	3,8		8
Geranium, scarlet	*Pelargonium hortorum*		9	9
Gerbera	*Gerbera* sp.	6		
Geum	*Geum* sp.	1,7	7	7
Japanese cudweed	*Gnaphalium japonicum*	6		
Gooseberry	*Ribes grossularia*	7	7	7
Grape	*Vitis vinifera*	7	7	7
Groundsel	*Senecio vulgaris*	6		
Hangehange	*Geniostoma ligustrifolium*			
Hawkbit	*Leontodon hispidus*	7	7	7
Heath	*Erica* sp.	7,8	9	7,8,9
Hinau	*Elaeocarpus dentatus*	5		
Hollyhock	*Althaea officinalis*	7	7,9	7,9
Honeysuckle	*Lonicera* sp.	7	9	7,9
Honeysuckle	*Lonicera nitida*	7	9	7,9
Hydrocotyle, native	*Hydrocotyle novae-zealandiae*	6		
Ice plant	*Mesembryanthemum* sp.	7	7	7
Inkweed	*Phytolacca octandra*		?	
Ivy	*Hedera helix*	7	7,9	7,9
Jasmin	*Jasminum* sp.	6		
Jasmin, native	*Parsonsia heterophylla*	3		
Jasmin, small-flowered native	*P. capsularis*	3		
Kahakaha	*Collospermum hastatum* (= *Astelia solandri*)		5	
Kamahi	*Weinmannia racemosa*	4,8		8
Kanuka, teatree	*Leptospermum ericoides*	3		+
Karamu	*Coprosma robusta*		4	
Kiekie	*Freycinetia banksii*			
Koromiko	*Hebe salicifolia*	6,8		8
Lavender	*Lavandula* sp.	7		7
Lilac	*Syringa vulgaris*	6,7	9	6,7,9
Lily	*Lilium* sp.		7,9	9
Linaria	*Linaria* sp.	1,7		7
Lotus	*Lotus angustissimus*	6	9	9
Lotus	*L. corniculatus*	1	9	9
Lotus	*L. hispidus*	6	9	9
Lotus major	*L. uliginosus*	6,8	9	8,9
Lucerne	*Medicago sativa*	3		3
Lupin, blue	*Lupinus angustifolius*		7,9	7,9
Lupin, tree	*L. arboreus*		7,9	7,9
Mahoe (whitey wood)	*Melicytus ramiflorus*	4		
Makomako (wineberry)	*Aristotelia serrata*		4,5	
Malva	*Modiola caroliniana*	7	7,9	7,9
Manuka	*Leptospermum scoparium*	3,8		8
Mapou (matipou)	*Suttonia australis*		4	
Marigold	*Tagetes* sp.	6		
Mayweed, rayless	*Matricaria discoidea*	6		
Milkweed	*Euphorbia peplus*	1,7	7	7
Mingimingi	*Leucopogon fasciculatus*			
Muehlenbeckia	*Muehlenbeckia australis*			
Mullein	*Verbascum* sp.	7	7	7
Nemesia	*Nemesia* sp.			
Nettle	*Urtica incisa*		+	
Nightshade, black	*Solanum nigrum*		+	
Niniwa	*Gaultheria oppositifolia*	+		
Onion	*Allium* sp.	7		7
Oxalis	*Oxalis corniculata*	1		
Oxalis	*O. stricta*	1		
Oxeye daisy	*Chrysanthemum leucanthemum*	7		7

Common Name.	Botanical Name.	Nectar Flowers.	Pollen Flowers.	Worked by Bees.
Pansy	*Viola tricolor*	1	9	9
Parsnip	*Pastinaca sativa*			
Pate (patete)	*Schefflera digitata*	4		
Patotara	*Leucopogon fraseri*	4		
Pea	*Pisum sativum*	6		
Peach	*Prunus persica*	7	7	7
Pear	*Pyrus communis*	7	7	7
Pearlwort, prostrate	*Sagina procumbens*	1		
Pennyroyal	*Mentha pulegium*	7,8		7,8
Pentstemon	*Pentstemon* spp.	6,7		7
Petunia	*Petunia* sp.			
Phlox	*Phlox* sp.	6		
Pigeonwood	*Hedycarya arborea*			
Pimpernel, scarlet	*Anagallis arvensis*		6	
Piripiri (bidibid)	*Acaena sanguisorbae*		4	
Piripiri, Australian	*A. ovina*		+	
Plantain, greater	*Plantago major*		2	
Plantain, narrow-leaved	*P. lanceolata*		7,9	7,9
Pohuehue	*Muehlenbeckia complexa*		+	
Polygala	*Polygala* sp	1		
Poplar	*Populus nigra*		6,9	
Poppy, field	*Papaver rhoeas*	7	7,9	7,9
Poppy, iceland	*P. nudicaule*	7		7
Poppy, opium	*P. somniferum*	7		7
Poppy, oriental	*P. orientale*	7	9	7,9
Poroporo	*Solanum aviculare*		+	
Potato	*S. tuberosum*		+	
Pratia	*Pratia angulata*	4		
Pukatea	*Laurelia novae-zealandiae*			
Purpletop	*Verbena bonariensis*	6,7		7
Ragwort	*Senecio jacobaea*	6		
Rangiora	*Brachyglottis repanda*	3		
Rata	*Metrosideros diffusa*	+		
Rauraki, sow-thistle	*Sonchus oleraceus*	7	7	7
Rewarewa	*Knightia excelsa*	3,8	3	8
Rhododendron	*Rhododendron* sp.	6		
Rose, briar (dog)	*Rosa canina*		1	
Rose, climbing	*R. multiflora*		7	
Rose, sweet briar	*R. eglanteria*		7	
Rose, tea	*R. indica*		7	
Rosemary	*Rosmarinus officinalis*	7		7
Salpiglossus	*Salpiglossus* sp.			
Salvia	*Salvia* sp.	7	9	7,9
Satureia	*Satureja vulgaris*	6		
Scarlet pimpernel	*Anagallis arvensis*		6	
Sedum	*Sedum* sp.	6		7
Self-heal	*Prunella vulgaris*	6		
Snowberry	*Gaultheria antipoda*	4		
Sorrel, sheep	*Rumex acetosella*		9	9
Sow-thistle	*Sonchus asper*	6		
Speedwell, field	*Veronica arvensis*	1,7	9	7,9
Spiraea	*Spiraea* sp.	7	7	7
Strathmore weed	*Pimelea prostrata*	4		
Strawberry, wild	*Fragaria vesca*	7	7	7
Supplejack	*Rhipogonum scandens*			
Sumac (poison ivy)	*Rhus* sp.	7		
Sweet William	*Dianthus barbatus*	6		
Tarweed	*Odontites viscosa*			
Tauhinu	*Pomaderris phylicaefolia*			
Tawa	*Beilschmiedia tawa*			
Thistle, Californian	*Cirsium arvense*	7	7	7
Thistle, Scotch (spear)	*C. lancolatum*	7	7,9	7,9
Thrift	*Armeria* sp.	6		
Titoki	*Alectryon excelsum*	8		8
Trefoil, haresfoot	*Trifolium arvense*	6		
Trefoil, hop	*T. campestre*	6		
Turnip, wild	*Brassica campestris*	7	9	7,9

Common Name.	Botanical Name.	Nectar Flowers.	Pollen Flowers.	Worked by Bees.
Tutu	*Coriaria arborea*		4	
Viburnum	*Viburnum* sp.		7,9	7,9
Guelder rose	*V. opulus*	6		
Viper's bugloss	*Echium* sp.	7,8		7,8
Virginia creeper	*Parthenocissus quinquefolia*	7	7	7
Viscaria	*Lychnis* sp.	1		7
Wallflower	*Cheiranthus cheiri*	6		
Walnut	*Juglans* sp.		7,9	9
Wattle	*Acacia longifolia*			
Willow, pussy	*Salix caprea*	7	7,9	7,9
Wireweed	*Polygonum aviculare*		+	
Yarrow	*Achillea millefolium*	7		7
	Hypericum japonicum			
	Stellaria parviflora	7		7

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THE AMMONIA AND NITRATE CONTENT OF GLASSHOUSE TOMATO SOIL UNDER DIFFERENT TREATMENTS

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(*Received for publication, 29th September, 1948*)

Summary

The effect of sterilization with steam, chloropicrin, D-D and gammexane on the ammonia and nitrate content of the soil was examined. These methods of sterilization differed in their effect on nitrification in the soil.

All methods of sterilization brought about increases in yield and growth. Gammexane at the rate used was the least effective. Differences in available nitrogen between sterilized and unsterilized plots did not seem to be sufficient to account for the differences in yield and growth. High ammonia nitrogen present in the early stages of plant growth in certain sterilized plots did not appear to affect the yield of fruit. Heavy dressings of cocoa husks increased growth and yield on unsterilized soil and increased the inorganic nitrogen level of the soil.

INTRODUCTION

IN studying the effect of soil sterilization on the growth of tomato plants and on the yield and quality of the fruit, determinations were made of the nitrogen present in the soil as ammonia and nitrate in certain glasshouse plots at different times during the growing season. Information was obtained on changes taking place in the available nitrogen content of the soil with different methods of sterilization and with certain modification of the standard fertilizer treatment.

Results are given in Tables I and II for six plots with different treatments in Glasshouse A sampled at intervals from August to December, and Table III gives figures for a number of plots in Glasshouse B where four methods of soil-sterilization were being compared.

TREATMENTS IN GLASSHOUSE A

The standard fertilizer treatment consisted of :—

(a) the applications of 4 oz. superphosphate and 2 oz. sulphate of potash per sq. yd. at the time of digging during the winter.

(b) the use prior to planting of a mixture supplying 2 oz. superphosphate 1 oz. sulphate of potash, $\frac{3}{4}$ oz. dried blood and $\frac{3}{4}$ oz. sulphate of ammonia per sq. yd.

Half this quantity was broadcast and forked in over the whole plot, and the other half was raked in along the trenches. The fertilizer was applied on 8th August and the plants were set out in the trenches on 21st August. A top-dressing of the fertilizer mixture at the previous rate, i.e., $4\frac{1}{2}$ oz. per sq. yd., calculated on the total area of the plot, was applied along the rows on 5th November.

Where cocoa husks were used, they were spread over the whole plot and dug into the top 6-8 in. after sterilization.

Steam sterilization was carried out to a depth of 12-14 in. The steam was applied at approximately 100 lb. pressure for about 5 minutes, i.e., until it came freely through to the surface. The date of steaming was 9th June. Chloropicrin was applied on 13th June. It was injected into the soil at a depth of 6 in. at the rate of approximately 6 ml. per sq. ft.

The experimental plots were treated as follows :—

PLOT A6 Steam-sterilized, standard fertilizer.

PLOT A8 Steam-sterilized, standard fertilizer except that the nitrogen was supplied as dried blood, cocoa husks (1947), 10 tons dry matter per acre.

PLOT A12 Chloropicrin-sterilized, standard fertilizer, cocoa husks (1947), 10 tons dry matter per acre.

PLOT A19 Unsterilized, standard fertilizer, cocoa husks (1946 and 1947), 10 tons dry matter per acre each year.

PLOT A20 Unsterilized, standard fertilizer.

PLOT A22 Steam-sterilized, standard fertilizer, cocoa husks (1947), 10 tons dry matter per acre.

The soil in this glasshouse and in glasshouse B had a pH of approximately 7 throughout.

SAMPLING OF THE PLOTS

Soil samples were taken with a half-inch soil borer in the trenches between the plants as near the line of the row as possible and each sample consisted of 12 to 15 cores to a depth of 9 in. Except where specified the time of sampling was between 8.30 a.m. and 10 a.m. and the nitrogen determinations were carried out the same day.

It may be pointed out that under glasshouse conditions it is more difficult to obtain an even distribution of applied nitrogen than in plot experiments. For this reason small differences in ammonia and nitrate content between samples may have little significance. In considering the ratio of ammonia nitrogen to nitrate nitrogen in the soil, the possibility that the plant may absorb one form of nitrogen more rapidly

TABLE I. GLASSHOUSE A. SEASON 1947-48

Ammonia and Nitrate Nitrogen in Glasshouse Tomato Plots in p.p.m. of dry soil

Plot Nos.	19 Aug.	1 Sep.	15 Sep.	30 Sep.	13 Oct.	28 Oct.	3 Nov.		17 Nov.	1 Dec.
PLOT A6. Steam-sterilized										
Ammonia nitrogen ...	89	95	46	25	7	5	7		57	7
Nitrate	7	31	52	51	51	39	32		22	27
Ammonia and nitrate nitrogen	96	126	98	76	58	44	39	TOP-DRESSED 5th NOVEMBER	79	34
Yield of fruit = 7.1 lb.										
PLOT A8. Steam-sterilized, Organic nitrogen, cocoa husks 1947										
Ammonia nitrogen ...	41	85	26	16	4	25	9		37	12
Nitrate	7	43	88	64	60	99	42		54	81
Ammonia and Nitrate nitrogen	48	128	114	80	64	124	51		91	93
Yield of fruit = 6.7 lb.										
PLOT A20. Unsterilized										
Ammonia nitrogen ...	63	28	8	8	1	2	2		21	3
Nitrate	22	86	110	73	38	90	52		74	56
Ammonia and nitrate nitrogen	85	114	118	81	39	92	54		95	59
Yield of fruit = 3.8 lb.										

	21 Aug.	3 Sep.	17 Sep.	1 Oct.	15 Oct.	30 Oct.	5 Nov.		18 Nov.	2 Dec.
PLOT A12. Chloropicrin, cocoa husks 1947										
Ammonia nitrogen ...	119	122	99	97	85	45	41		78	39
Nitrate	2	4	6	8	13	31	32		52	55
Ammonia and nitrate nitrogen	121	126	105	105	98	76	73	TOP-DRESSED 5th NOVEMBER	130	94
Yield of fruit = 7.5 lb.										
PLOT A19. Unsterilized, cocoa husks 1946 and 1947										
Ammonia nitrogen ...	54	13	13	6	5	2	4		28	8
Nitrate	54	115	133	92	112	109	101		89	111
Ammonia and nitrate nitrogen	108	128	146	98	117	111	105		117	119
Yield of fruit = 5.5 lb.										
PLOT A22. Steam sterilized, cocoa husks 1947										
Ammonia nitrogen ...	81	54	19	11	8	10	8		55	16
Nitrate	14	55	68	53	51	44	35		47	54
Ammonia and nitrate nitrogen	95	109	87	64	59	54	43		102	70
Yield of fruit = 7.7 lb.										

NOTE: Yields expressed as average per plant for the whole season.

than another must be borne in mind. However, from the results in Table I certain general conclusions may be drawn.

1. The applied nitrogen was converted rapidly into nitrates in the unsterilized soil, so that by the middle of September most of the available nitrogen in Plots A19 and A20 was in the nitrate form.

2. Steam delayed the nitrifying process as may be seen from the ammonia figures for 1st September.

3. Chloropicrin at the rate used in Plot 12, i.e., 6 ml. per sq. ft. was more effective than steam in delaying nitrification. By early November when the top-dressing was applied, there was still more nitrogen present as ammonia than as nitrate in this plot.

4. Dried blood applied to steam-sterilized soil rapidly gave rise to ammonia (Plot 8), showing that organisms capable of bringing about the decomposition of organic nitrogen compounds to the ammonia stage were active when the fertilizer was applied.

5. Even after the nitrifying power of the soil appeared to be completely restored, the nitrogen of the top-dressing (applied on 5th November) was changed to nitrate more slowly where the soil had previously been sterilized than on unsterilized plots. Thus on 17th November, the sterilized plots gave ammonia figures from 37 to 78, averaging 57 p.p.m. of nitrogen while the amounts found in the unsterilized plots were 21 and 28 p.p.m.

6. From a consideration of the figures for total ammonia plus nitrate nitrogen, it seems improbable that the increase in available nitrogen which results from soil-sterilization provides an adequate explanation of the large increases in yield obtained where steam or chloropicrin had been used. In the unsterilized plot A20 where the yield averaged only 3.8 lb. per plant compared with 7.1 lb. for a steamed plot with the same fertilizer treatment (A6), the soil in the trenches was well supplied with available nitrogen throughout the period of the experiment. The most consistently high level of available nitrogen was found in the unsterilized plot A19 where cocoa husks at the rate of 20 tons per acre in two years and equivalent to approximately 600 lb. of nitrogen (N) per acre each year had been applied. This plot gave a yield of 5.5 lb. per plant compared with 3.8 lb. for the unsterilized plot without husks (A20); but the improvement in both growth and yield was not as great as that produced by steam sterilization (A6). Cocoa husks are a rich source not only of nitrogen but of other plant foods. The beneficial effect of soil-sterilization seems to be due more to the destruction of root diseases and the consequent stimulation of fine root growth than to any other factor in the Nelson tomato soils.

On 17th November the 9 to 15 in. depth in three plots was analysed. Table II gives a comparison between the 0-9 in. and 9-15 in. depths at this time.

TABLE II. AMMONIA AND NITRATE NITROGEN CONTENTS OF THE 0-9 IN. AND 9-15 IN. DEPTHS OF SOIL

Depth.	Ammonium N p.p.m.			Nitrate N p.p.m.		
	Plot A6	Plot A8.	Plot A20.	Plot A6.	Plot A8.	Plot A20.
0 - 9 in.	57	37	21	22	54	74
9 - 15 in.	14	13	9	5	9	9

It appears that on this type of soil under the fertilizer system used, the concentration of ammonia and nitrate nitrogen in the soil below the top nine inches is small.

TREATMENTS IN GLASSHOUSE B

All plots tested for available nitrogen in Glasshouse B had been given the standard fertilizer treatment. With the exception of plots B3 and B5 they had received 10 tons per acre of cocoa husks on the dry matter basis in 1946 and 10 tons in 1947. Plot B3 had no husks in 1946 and a heavy dressing of 30 tons per acre in 1947. Plot B5 had no husks in 1946 and 10 tons per acre in 1947.

STERILIZATION

Steam :

Steaming was carried out as in Glasshouse A. The date of steam treatment was 6th June.

D-D :

D-D was injected into the soil at a depth of 6 in. at the rate of 5 ml. per sq. ft. on 18th June.

Chloropicrin :

Chloropicrin was injected into the soil at a depth of 6 in. at the rate of 4 ml per sq. ft. on 16th June.

Gammexane :

Gammexane was used at the rate of 10 lb. per acre containing 10 to 12 per cent. active agent. Half the quantity was dug into a 6 in. depth, a quarter broadcast and forked and a quarter left broadcast on the surface. It was applied on 16th June.

TABLE III. GLASSHOUSE B. SEASON 1947-48

Effect of Different Methods of Sterilization on the Formation of Nitrate in the Soil
Results expressed as nitrogen in p.p.m. of the dry soil

	Plot B2.	Plot B3.	Plot B4.	Plot B5.	Plot B6.	Plot B7.	Plot B8.
	ST	U 30H	D-D	CL	U	GA	ST
SAMPLED 13th OCTOBER*							
Ammonia nitrogen ...			83	15		2	6
Nitrate nitrogen			13	75		51	89
Ammonia and nitrate nitrogen			96	90		53	95
SAMPLED 21st OCTOBER							
Ammonia nitrogen ...		17		34	2	2	
Nitrate		149		73	61	73	
Ammonia and nitrate nitrogen		166		107	63	75	
	TOP	DRESS	ED 4th	NOVE	MBER		
SAMPLED 3rd AND 4th DECEMBER							
Ammonia Nitrogen ...	13	23	40	28	9	17	10
Nitrate	63	119	57	63	62	77	77
Ammonia and nitrate nitrogen	76	142	97	91	71	94	87
SAMPLED 16th AND 17th DECEMBER							
Ammonia nitrogen ...	11	10	20	15	6	4	
Nitrate	40	93	50	52	39	34	
Ammonia and nitrate nitrogen	51	103	70	67	45	38	
Average yield of fruit in lb. per plant	8.5	7.1	7.4	8.3	4.9	6.5	7.7

ST = Steam
CL = Chloropicrin
U = Unsterilized
30H = 30 tons cocoa husks per acre
GA = Gammexane

* Samples on 13th October were taken in the late afternoon and analyses carried out next morning.

The results show that the effect on the nitrifying power of the soil was most noticeable with D-D. Nitrification was less retarded with chloropicrin and least with steam and gammexane. Observation showed that where sterilizing agents retarded the change from ammonia to nitrate so that the main supply of inorganic nitrogen to the plant was in the form of ammonia for a long period, the plants tended to be less vigorous than on other sterilized plots. Thus the slowest-growing plants on sterilized soil during October and November were found with D-D (plot 4) in glasshouse B and with chloropicrin (plot 12) in glasshouse A. The final yield of fruit, however, was not adversely affected. Whether the tomato plants grew more vigorously with nitrate than with ammonia or whether the retarded growth in plots B4 and A12 was due to toxic residues left in the soil after sterilization with chloropicrin or D-D has not been determined. It was noticed that a garlic-like odour was given off from plot B4 when sterilized by steam a year after the D-D treatment.

Under the conditions of the experiment, steam and chloropicrin were the most effective and gammexane the least effective sterilizing agents in increasing fruit production (Table II). As in glasshouse A, an improvement in growth and yield was associated with the use of cocoa husks on unsterilized soil. Plot B3 where 30 tons of husks had been applied in the 1947-48 season, instead of the standard 10 tons, gave a yield of 7.1 lb. per plant compared with 4.9 lb. for the unsterilized plot on the standard treatment, and plant growth was more vigorous. The highest figures for available nitrogen were for this plot, but the effect of the heavy dressing of cocoa husks on growth and yield was not as marked as that produced by sterilization with steam or chloropicrin.

ACKNOWLEDGMENT

The authors wish to thank Mr. J. Robinson for assisting with the chemical work.

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